THE PLANT DISEASE REPORTER

Issued By

THE PLANT DISEASE SURVEY

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

BOTRYTIS DISEASES OF GLADIOLUS

Supplement 224 May 15, 1954

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THE PLANT DISEASE REPORTER SUPPLEMENT

Issued by

THE PLANT DISEASE SURVEY
SECTION OF MYCOLOGY AND DISEASE SURVEY

Horticultural Crops Branch
Supplement 224

Plant Industry Station, Beltsville, Maryland
May 15, 1954

BOTRYTIS DISEASES OF GLADIOLUS[1]

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BOTRYTIS DISEASES OF GLADIOLUS

Charles J. Gould

INTRODUCTION

This article was originally prepared to facilitate discussion on the Botrytis diseases at the Gladiolus Disease Symposium sponsored by the North American Commercial Gladiolus Growers at Cleveland, January 14, 1953. It is primarily a literature review, but contains some unpublished data of the author and others. Data on the effects of relative humidity, temperature, and other factors on the gladiolus corm during storage are included because they are related to disease control.

IMPORTANCE

Although, according to Timmermans (70)[3], Sorauer described a Botrytis disease of gladiolus in 1898 and Ritzema Bos listed Botrytis on gladiolus leaves in 1914, the disease was practically unknown to gladiolus growers twenty-five years ago. Since that time, however, it has become increasingly important.

CORM ROT: Timmermans (70) stated that the disease suddenly became very harmful after 1937 in Holland. She attributed this to more favorable weather for the fungus, use of new and more susceptible varieties, and the lack of sufficiently good storehouses. Stofmeel (68) reported heavy losses in Holland in the winters of 1937/38, 1939/40, and 1940/41. Van de Pol and Flipse (71) stated that in 1948 *Botrytis gladiolorum* was still one of the limiting factors in gladiolus culture in Holland. However, a more recent Dutch publication (3) reported that better handling had resulted in a decrease of Botrytis attack.

Comments by English workers in 1950 to the writer indicated that it was the number one disease in their country. Wade (72) in 1945 in Australia listed losses of more than 50 percent of susceptible varieties during years favorable for the fungus. Drayton (31) in Canada reported in 1946 that prior to 1941 the only *Botrytis* seen was in corms imported from other countries. "During the last few years, however, several cases have been reported from Ontario by some of the larger growers and on each occasion the losses in several varieties have been severe."

The disease has also been very destructive in many areas of the United States. Baker (5) reported in 1948 that the Botrytis disease had become a limiting factor in gladiolus production in California. McWhorter (see 54) stated in 1948 that "...soft rot, due to *Botrytis cinerea* and possibly other species, has been the most destructive gladiolus disease in Oregon. Total loss from this disease has exceeded in one year the losses from all other diseases in five years." Hubert and Wheeler (40) in a summary of results of a disease survey of domestic-shipped corms by the Bureau of Entomology and Plant Quarantine during the winter of 1948/49, found *B. gladiolorum* once each in shipments from Florida, Maryland, Massachusetts, New Jersey, and New York, and in nine cases from Michigan. Three thousand, two hundred and eighty-one cases were involved in this survey and 451 cases were examined. No other species of *Botrytis* was found by them in rotted corms. Forsberg (35) stated that gladiolus growers in Kankakee County (Illinois) lost thousands of dollars from Botrytis rot during the winter of 1950/51.

In 1950 the writer (36) obtained estimates from scientists in several States and Canada of the average loss due to Botrytis corm rot. These ranged from a trace in Michigan and upstate New York, 0.4 percent in Florida, 1 percent in New Jersey, 1.5 percent in North Carolina and British Columbia, to 3 percent in western Washington.

LEAF AND FLOWER BLIGHT: Several epiphytotics of leaf blight have been reported in various areas of the United States, especially Florida and coastal areas of southern California and the Pacific Northwest. Magie (50) estimated that the combination of *Botrytis* and *Curvularia* alone on leaves and flowers was responsible for a million-dollar loss in the United States in 1950.

Over the United States as a whole, flower infection is probably of more economic importance than is corm rot. The former is particularly serious in Florida where millions of spikes are shipped to northern markets every year. The cut spikes may exhibit no symptoms before packing, but infection progresses rapidly under the cool moist conditions in hampers shipped in refrigerated cars or trucks, leading to considerable dumpage at destination. As an example,

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[3] Numbers within parentheses refer to Literature Cited.

Nelson (58) stated that "... during the winter of 1947, certain light-colored varieties were boycotted on the Chicago market for a time while Botrytis blight was ruining those sent to market. The spotting developed in transit..." According to Bald (13) the neck rot phase is common in southern California during autumn, winter and spring under certain conditions.

Sufficient reports are available to indicate that the Botrytis disease probably exists in every area of the world where gladiolus is grown. They also indicate that severe attacks are limited, presumably owing to climatic conditions, and that the leaf blight phase may occur (as in Florida) without appreciable corm rot. Conditions relating to this will be described later.

THE ORGANISMS

Of the several species of Botrytis that have been found on gladiolus, probably B. gladiolorum and B. gladioli have been listed most frequently. The status of these two was described as follows by McClellan, et al. (54):

"Klebahn (41) described Botrytis gladioli Kleb. in 1930, and Timmermans (70) described B. gladiolorum Timmermans in 1942. Botrytis gladioli differs from B. gladiolorum mainly in the shape of the conidia which are long and narrow, averaging 10.4 µ x 4.7 µ, whereas conidia of the latter species are ovoid to subglobose and average 15 µ x 10 µ. Conidia of the Botrytis isolated by Moore (57), by Hawker (38), by Dodge and Laskaris (29), and by us correspond with those of B. gladiolorum (conidia from our isolates average 14.7 µ x 9.8 µ). Wade (72) called the Botrytis he studied B. gladioli, but presumably it was B. gladiolorum since his spore measurements and other morphological evidence agree with Timmermans' organism rather than with Klebahn's. Miss Hawker (38) considered her isolates to be strains of B. cinerea but the spore measurements she gives agree with Timmermans' B. gladiolorum. Dennis and Wakefield (21) described the perfect stage of Botrytis isolated from a gladiolus corm by W. Buddin as Sclerotinia Draytoni Dennis and Wakefield. They described the conidia as narrowly elliptical and 8-16 µ x 5-7.5 µ. These spore measurements agree with those of B. gladioli. Drayton obtained single ascospore cultures from Buddin and in a personal communication to us states, 'After making a number of measurements, Dr. Groves and I are of the opinion that Botrytis gladiolorum is the conidial stage of Sclerotinia (Botryotinia) Draytoni, and that this is the fungus responsible for the early-storage decay.' Parallel inoculations of Picardy gladiolus corms with one of Buddin's isolates (163-K) obtained by us from Drayton and with one of our own isolates (213-D) have given similar infection. ...Botrytis gladioli is poorly described and no mention is made of its effect on the plant. Timmermans points out that Klebahn mounted his spores in glycerine and his measurements might have been greater had the spores been mounted in water."

Peiris (59) stated that the descriptions of isolates of Botrytis from gladiolus by previous workers (except Klebahn's B. gladioli) were all similar to B. gladiolorum and were probably that species. Peiris's isolates of Botrytis from diseased gladiolus were in the proportion of 99 to 19 for gladiolorum and cinerea, respectively. Seventy-nine percent of the cinerea isolates but only 45 percent of the gladiolorum isolates were from above-ground parts. The only species listed by Weiss and O'Brien (75) in their Index of Plant Diseases in the United States are B. gladiolorum recorded from California, Florida, Massachusetts, Maryland, Michigan, New Jersey, New York, Oregon, Washington, Wisconsin, and Alaska, and B. elliptica from Washington. Schmidt (66) identified the Botrytis causing a corm rot in Austria as B. gladiolorum.

MacLean reported (46) finding Botrytis gladiolorum, B. gladioli, B. elliptica and B. cinerea on gladiolus in Washington in 1947. B. cinerea has been reported on gladiolus by other workers. McWhorter (56) stated in 1939 that a strain of B. cinerea attacked maturing gladiolus foliage in a field near Portland and commented that "... this is the first record we have of Botrytis attacking gladiolus foliage in Oregon." He (see 54) also referred to the corm rot in Oregon in 1948 as being caused by B. cinerea and possibly other species. Weiss (74) stated in 1940 that a rot of gladiolus corms grown on Long Island was apparently caused by B. cinerea. Dimock (28) said that an epiphytotic of leaf blight and flower spotting in Florida in 1940 was apparently caused by a Botrytis of the cinerea type. Timmermans (70) isolated B. cinerea only once (that time from blooms).

B. cinerea was found by MacLean (46) in 1947 on 62 ornamental hosts, including gladiolus. Isolates of this species from 17 different hosts were able to infect the above-ground parts of gladiolus. Only one isolate was incapable of causing infection. Seedling gladiolus were most susceptible. MacLean summarized his tests with B. cinerea as follows: "Each of the hosts tested was parasitized to some degree by at least one of the eighteen collections of Botrytis

cinerea used in the tests. Many of the collections of Botrytis cinerea proved to be very pathogenic on a great variety of hosts." ... and concerning gladiolus, "The results of these experiments add further proof to the statements made by many workers in the field that Botrytis cinerea is very possibly responsible for much of the above-ground spotting of the plants in the field."

In comparative tests Peiris (59) found that B. gladiolorum was more pathogenic to gladiolus than B. cinerea but that the latter was capable of causing some infection. In comparable tests with the two species on roots of rutabaga and turnip and corms of gladiolus, B. cinerea was definitely more pathogenic to the former and B. gladiolorum to the latter.

Botrytis elliptica was found by MacLean (45) causing leaf spots on gladiolus in western Washington in 1947.

MacLean (46) made several cross-inoculation tests with 11 different species of Botrytis on 12 types of bulb or corm hosts. The results on gladiolus are contained in Table 1. Flowers were susceptible to attack by many species, but leaves, stems, and even corms were affected by species other than those normally occurring on gladiolus. In general, those species that had been found naturally occurring on gladiolus (B. gladioli, B. gladiolorum, B. cinerea, and B. elliptica) produced the most damage.

On the basis of the experiments and observations by MacLean and others, it would appear that generally most corm rot and much of the leaf and flower spotting is caused by B. gladiolorum, but that B. cinerea may occasionally be responsible for some damage to leaves and flowers. The position of B. gladioli, B. elliptica, and other species is uncertain but probably minor.

HOSTS OTHER THAN GLADIOLUS

Timmermans (70) isolated Botrytis gladiolorum from crocus bulbs, spots on Freesia leaves, and Montbretia plants.

A summary of MacLean's data (46) (Table 2) indicates that B. gladioli and B. gladiolorum can attack a number of other bulb or corm hosts under certain conditions. The flowers were most susceptible in his tests, but sometimes leaves and even corms and bulbs were affected.

For comparative purposes in this discussion, brief descriptions (from MacLean, 46) of the following Botrytis species are included:

Botrytis elliptica ... "The conidiophores of Botrytis elliptica are numerous, 1-3 mm. long, branched, with pale brown walls, and they bear at their tips clusters of elliptical, hyaline, later sometimes pale brown conidia averaging 24 x 16 µ; with a range of 20-25 x 14-16.5 u (16-34 x 10-24 µ according to Westerdijk and van Beyma). ...The sclerotia are somewhat irregular in size and shape, and shining black..."

Botrytis gladioli. "The conidiophores are up to 2 mm. long, dark brown below, and swollen at the tips into comparatively small ampullae bearing jagged or toothed sterigmata from which cylindric-ellipsoidal conidia measuring 8-15 x 3-6 µ (Av. 10.4 x 4.7 µ) are abstricted. . . The sclerotia are whitish when young, later become gray and finally black. They are often aggregated into coralloid masses on top of the corm..."

Botrytis gladiolorum. "The conidiophores are brown in color although not a dark brown, lighter at the top, bearing conidia on ampullae situated along the conidiophores. The conidiophores are about 20 µ thick at the base. The conidia are hyaline, smooth, oval to egg-shaped, sometimes nearly round, single-celled, and measure 12-15 x 9-12 µ (Av. 15 x 10 µ). The sclerotia are small to large and are black..."

Botrytis cinerea. "The conidiophores are slender, constricted at the septa, gregarious, simple or sparsely branched, erect and cinerous. They bear globose pale conidia that measure 4.6-7.5 x 7.5-13.1 µ. The sclerotia range from dark gray to black and vary in size from very small up to one-quarter inch in diameter."

Table 1. Results of cross-inoculation studies by MacLean (46) with Botrytis species other than B. cinerea on gladiolus:

Botrytis species	Inoculations on: Flowers	Cut flower stems	Leaves and stems	Corms: (soil inocu-lations
B. tulipae	0	2	2	0
B. narcissicola	2	T	T	0
B. elliptica from Colchicum sp.	2	3	3	0
B. elliptica from Lilium sp.	3	3	3	1
B. gladioli	2	2	2	3
B. gladiolorum	4	3	4	3
B. croci	4	0	T	0
B. galanthina	4	0	0	0
B. hyacinthi	2	0	0	0
B. cinerea f. convallariae	4	0	2	T
B. convoluta	0	0	0	2
B. polyblastis	0	0	0	0

0 = no symptoms, apparently immune
T = resistant, only a few spots present
4 = highly susceptible
1, 2, 3 = intermediate degrees of susceptibility

Table 2. Results by MacLean (46) of inoculation studies with Botrytis gladioli and B. gladiolorum on various hosts:

Host	B. gladioli: Portion of plant inoculated				B. gladiolorum: Portion of plant inoculated			
	Flowers	Flower stems	Leaves and stems	Corms: (soil inocu-lations)	Flowers	Flower stems	Leaves and stems	Corms (soil inocu-lations)
Tulip	2	T	T	1	2	2	1	3
Narcissus	2	0	T	2	3	1	1	3
Iris	2	-	T	0	2	-	1	0
Lilium	0	-	0	2	1	-	0	T
Gladiolus	2	2	2	3	4	3	4	3
Hyacinths	2	-	0	0	2	-	0	2
Crocus	2	-	T	2	4	-	T	1
Convallaria	0	-	T	1	0	-	T	0
Colchicum	0	-	0	0	0	-	0	0
Scilla	2	-	0	2	2	-	0	2
Muscari	1	-	0	2	2	-	0	0
Freesia	2	-	T	T	2	-	T	0

0 = no symptoms, apparently immune
T = resistant, only a few spots
4 = highly susceptible
1, 2, 3 = intermediate degrees of susceptibility

PHYSIOLOGY OF BOTRYTIS GLADIOLORUM

According to Timmermans (70) the growth of the fungus on agar was weak at 37° F.,[4] ceased at 86°, and was optimum between 68° and 72.5°. She also ran pH tests on prune agar (between 4 and 8.5) and found strongest growth between 5 and 5.5.

Peiris (59) found the best medium for sporulation of B. gladiolorum to be a decoction of gladiolus leaves and glucose-peptone, kept in good light and under moderate drying conditions.

SYMPTOMS

LEAVES: Leaf spots show a wide variation in size and shape (Fig. 1, 2). They may be oval or circular, pinpoint in size, or large (over 1/2 inch) and irregular. They usually have a brown or grayish-brown center that is often covered with a gray mass of spores. The margin of small spots is usually definite and dark brown, reddish-brown, or even red, but large spots more often have an indefinite margin. Large spots on leaves and stems may cause a yellowing and eventual death of the terminal portions.

Experiments by MacLean (46) indicate that infection of gladiolus leaves by the different species of Botrytis results, in general, in similar symptoms. However, the common parasites

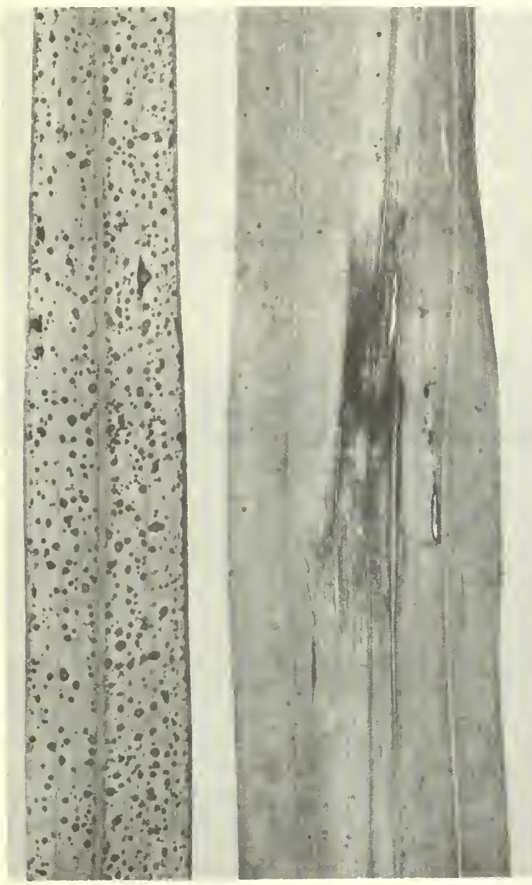

FIGURE 1. Different types of leaf spots on gladiolus caused by Botrytis gladiolorum.

FIGURE 2. Infection of gladiolus leaves and flower spike by Botrytis gladiolorum. Note decay of margins of petals.

4 In order to facilitate comparisons, all temperatures, including those in quoted material, have been converted to °F.

such as _B_. _gladiolorum_ were capable of producing the largest spots whereas smaller spots were generally due to the uncommon species such as _B. tulipae_.

The variation in size, shape, and color of the leaf spots have been confusing. MacLean's results may explain some of the variation. In addition, McClellan, _et al_. (54) have demonstrated that insofar as _B. gladiolorum_ is concerned much of the variation is related to temperature during and after infection. Thus, at 35° the spots were only pinpoint in size; at 40° and 45° they were also small but tended to coalesce and become larger after six to ten days; at 55° and 65° the lesions increased more rapidly in size; at 75° infection was slight.

Sometimes it is difficult to isolate the fungus from the small lesions that fail to increase in size. Bald (7) has stated that: "On the leaves of gladioli Botrytis produces dead spots of two kinds, small spots and big spots. In each of the small spots, one or two fungus threads of hyphae become established at the center and immediately under the leaf surface. These hyphae can be killed by warm weather, and often are: thus weather may fight for the grower as well as against him." Also, according to Bald (13) leaves may resist infection by the precipitation of gum in affected cells during periods of warm dry weather.

In the tests by McClellan, _et al_. (54), already mentioned, considerable infection occurred within 24 hours after the plants had been inoculated and held in a moist chamber. Within 120 hours the leaves were completely killed. Magie (47) has stated that a 13-hour humid period (furnished by dew) was sufficient to allow infection.

Bald (8) has recently published some interesting observations and experiments on the method of infection by _Botrytis gladiolorum_. He found that drops of water may be exuded through the stomata of gladiolus leaves. This occurs when the atmosphere is cool and humid and the soil is warm and moist. On vigorous plants in damp soil under highly humid conditions the droplets may even overflow, forming a heavy deposit of drops and films of water. On plants in dry soil the droplets are very small or lacking. The droplets readily permit the germ tubes of the fungus to pass into the stomata and infect the leaf. When leaves remain continuously wet the germ tubes enter the leaf directly through the cuticle.

Magie (47) indicated that leaf infection of Picardy and Maid of Orleans varieties was greater in those plots receiving normal fertilization than in those receiving low nitrogen or no fertilizer. He also mentioned in a recent letter (December 9, 1952) that plants infected with a virus are more susceptible than are healthy plants.

FLOWERS: Flowers are very susceptible to attack. The infection often begins as a small water-soaked spot, usually near the edge of the petal (Figs. 2 and 3). The spot may enlarge rapidly and become rather slimy. The fusion of several spots rapidly converts the flower into a drooping mass of tissue that is soon covered under moist conditions with a gray mass of spores. The color of these spots has been reported as varying from white (watersoaked) to brown, and sometimes white with a light brown or violet-colored border.

Magie (47) stated that a six-hour wetting period was sufficient for petal infection and that the infection may appear within 14 hours after inoculation. In 1948 he found some infection of open florets in Florida as late as May when the minimum temperatures averaged 65° and the mean temperature was 76° F for the month.

NECK: If infection occurs at or near the soil level, it may progress inward through the leaf bases and rot the stem. This often results in a gradual yellowing and eventual death of the upper part of the plant. Under moist conditions the rot is wet and brown, with the outer surface often covered with a gray "fuzz" of spores. Under dry conditions the area is dark brown and firm with a definite margin, and lacks the spore fuzz. The outer leaf bases may become shredded, somewhat as with dry rot but without the minute black sclerotia of the dry rot fungus. This neck infection may come from diseased corms, in which case it usually appears soon after the plants emerge; or it may come from air-borne spores, with the time of infection dependent upon suitable climatic conditions. According to Bald (13) neck-rot infection very seldom comes from infested soil.

Bald (7) has stated that: "The most serious aspect of Botrytis neck rot is not the killing of a few plants; it is that affected plants provide a unique source of spores, largely protected from sprays, able to persist during weather unfavorable to the disease. The importance of neck rot plants in a crop is far greater than their numbers. ... A single neck rot plant can produce millions of spores -- we have made estimates of the numbers of spores present at one time on a neck rot plant, and have obtained figures between half a million and several million. Such numbers of spores can be produced by cool humid conditions on a previously quiescent neck rot lesion in 24 to 48 hours."

FIGURE 3. Lesions caused by Botrytis gladiolorum on a light-colored flower (left) and a dark-colored flower (right) of gladiolus.

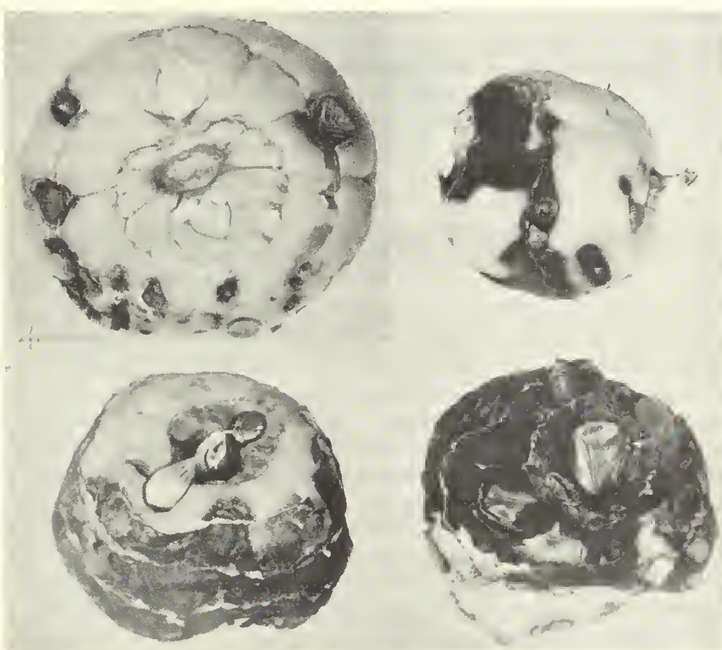

FIGURE 4. Gladiolus corms with different degrees of infection by Botrytis gladiolorum.

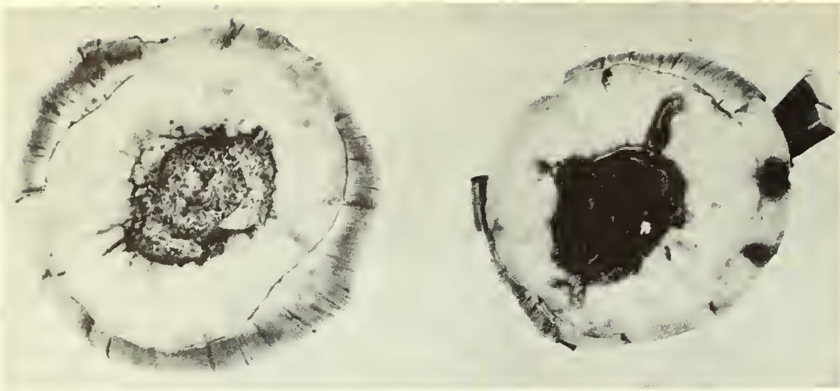

FIGURE 5. Core or "doughnut" type of gladiolus corm rot. (Botrytis gladiolorum).

FIGURE 6. Cross section of gladiolus corm affected with spongy type of decay caused by Botrytis gladiolorum.

CORMS: Several types of symptoms observed on corms (Fig. 4) were formerly attributed to different causes but are now recognized as different expressions of attack by the same organism. The earliest stages of infection may easily be overlooked. The different symptoms are: (a) occasional brown discoloration of basal plate; (b) one or many brown vascular bundles extending up to the stem area; (c) core partially or completely rotted, with or without surrounding tissue also rotted, and with or without infected brown vascular strands radiating to the surface (Fig. 5); this rot may result in the core falling out or becoming completely decomposed, leaving a doughnut-type condition); (d) light, watersoaked, straw-colored, greenish brown to dark brown spots on the surface, with a watery, greenish indefinite margin or with a definite brown, and usually sunken margin (arrested lesions are usually brown, sunken and firm); and (e) a general spongy decay (Fig. 6).

The decay varies from soft to rather fibrous and firm, apparently depending upon moisture and temperature. Under certain conditions, the husks may appear normal, but the corm underneath will be completely rotted. At an early stage water can easily be squeezed from such a corm, but later it gradually dries into a mummy or disorganized mass of dead tissue. Under optimum humidity conditions the fungus produces a mass of white, cottony mycelium underneath the husk. Sometimes, but not always, black sclerotia are formed, and less often conidia. The husks may be brown and split. When infected corms are planted, some produce healthy shoots while others die or give rise to weak, yellow shoots that often die. Baker and Sciaroni (6) and others have stated that the fungus will grow from corm to corm in storage.

Hawker (38) observed that when the old stem base could usually be lifted out leaving a clean

depressed scar the corms were healthy, but when this could not be done the corms often developed core rot later, especially with the varieties Picardy and Yvonne.

Bald (10) found that when remnants of tissue from the parent corms remained attached to the basal scars of daughter corms at normal cleaning time the probability was high that Fusarium or some other pathogenic organism had penetrated through such basal scars into the new corms.

The different types of corm rot were shown by McClellan, et al. (54) to be at least partially caused by temperature differences. Corms held at 45° F or warmer had darkened husks and dark rotted portions, whereas at 35° the husks and rotted portions were lighter in color and the rot was not so well defined.

Histology of Infected Area -- Bald (10) found considerable varietal difference in the reaction of corms to invasion by Botrytis. He stated that: "On the corms of some, e. g. Lady Jane..., large dark brown surface blemishes occurred and there was relatively little penetration of the tissues. Mycelium was mainly subcuticular, several layers of cells were killed by toxic action, and internally a periderm layer was formed. Vascular invasion was often restricted. In other varieties, e. g., Helen Mayne..., vascular bundles and parenchymatous tissues were readily invaded, and the core often rotted out. Water-soaking of tissues at the margin was a regular feature of Botrytis lesions expanding through storage tissues in this and similar varieties."

Wade (72) stated that the Botrytis entered the corm along vascular bundles from either the cut stem end (most common) or through the old corm, but never through parenchymatous tissue. Timmermans (70) apparently also found most penetration occurring through the cut stem end but stated that spots developed on the upper corm surface that were not always connected with a rotted core. This is supported by Hawker's (38) observations. Drayton (31) believed that attack could take place at any point, but perhaps most frequently in the region of the basal plate. Peiris (59) concluded that infection occurred primarily either through the cut stem end or through the scar if the stem was removed, but that some could take place through the old corm or basal scar. Bald (10) found that the most frequent points of origin of lesions on the larger corms appeared to be the leaf scars and the bases of flower stalks. In inoculation tests Hawker (38) obtained more infection of wounded than nonwounded corms and more at the neck or base than at the side. Peiris (59) also found that wounded corms were more susceptible than unwounded ones. Wade (72) did not believe that soil infection was important but Hawker (38) found that some apparently could occur.

Bald (10) has reported that: "In both foliage and corm tissues Botrytis mycelium was often subcuticular..., and in superficial lesions might not penetrate noticeably between the living cells. Where discoloration followed the vascular bundles, long stout hyphae were found running parallel with the bundles along the walls of parenchymatous cells rather than internally along the vessels. As breakdown of these tissues occurred, Botrytis mycelium ramified and penetrated the vessels. Botrytis often grew superficially between enfolding leaf bases, particularly under wet conditions. This sort of mycelial growth probably accounted for numerous infections in vegetative buds of corms held during winter on piled-up trays in the field. Lack of dormancy under cool conditions allowed some development of vegetative buds on the corms immediately after digging. The incidence of bud lesions suggested infection from the enfolding leaf scales, either by penetration into the meristematic tissues, or at the junction between meristematic tissues and the storage tissues of the corm. Having penetrated, the mycelium frequently progressed along the vascular bundles leading inwards from the buds..."

Wade (72) described the histology of corm rot as follows: "In active lesions the middle lamella of the cells of diseased parenchymatous tissue had been destroyed and the cells greatly distorted. The cell contents showed no definite structure but contained an accumulation of starch granules. At the edge of diseased lesions there is usually a sharp line of demarkation between the almost completely disorganized diseased tissue and the surrounding normal tissue... The mycelium of the fungus was abundant in the disorganized tissue and sometimes penetrated to a depth of several cells into apparently normal tissue.

"In some sections, however, there was a layer of cells containing a reduced number of starch grains, between the infected tissue and the normal tissue... The infected tissue contained an accumulation of starch granules and there was no suberinized layer at the edge of the healthy tissue. It therefore differed from the histological structure of arrested lesions, which will be described later.

"As previously stated the disease travels along the vascular bundles. The phloem tissue of the infected bundles is rapidly disintegrated and later the wood vessels are attacked and destroyed...

"Infected tissue of corms, in which the disease has been arrested differs in several respects

from those just described. The severely infected tissue is similar to that in actively growing lesions but no starch granules are present. It is surrounded by a layer of cells about 1 to 2 mm. wide, which have practically no cell contents and very few starch grains, but the cell walls do not show marked distortion. This layer of cells only contains a few hyphae of the organism. At the edge of these cells there is a layer of rectangular suberinized cells and beyond that the tissue is normal..."

Timmermans (70) stated that even the diseased vascular bundles may be surrounded by corky tissue.

Wade (72) found that the capacity of Botrytis to utilize pectin explained the rapid disorganization of infected tissue. Additional results of other tests on the chemistry of the host and physiology of the fungus are reported in his article and that of Timmermans (70).

Effect of Temperature on Infection -- The optimum temperature for infection of freshly harvested corms was 35° F in tests by McClellan, et al. (54). Some infection occurred at 45° but none at 55°, 65°, or 75°. Drayton (31) found that infection was more rapid at 38° to 45° than at higher temperatures. However, he was able to obtain some very small lesions on newly dug corms at 60°. Recently dug corms, inoculated with Botrytis, were completely rotted within ten days at 40° in his tests. Simmons (67) has stated that "while the growth rate increased regularly from 32 to 62° F., [on agar] the progress in the corm reached a maximum at 45° and fell off from that point until at 62° it was little higher than at 32°." Peiris (59) obtained most infection at 59° (88 percent); less at 41° to 50° (50 percent); and least at 68° to 77° (10 percent).

There is a marked difference between the optimum temperature for infection and that for growth of the fungus in culture. This attributed to the formation by the corm of the suberin and cork layers that wall off the infection. These will be discussed in a later section.

Relation of Time of Digging to Corm Rot -- In areas such as western Washington Botrytis rot is more prevalent on corms dug late in the season than on those dug early. Thus in experiments by Gould (54) at Puyallup in 1946, the loss from Botrytis of corms dug at two-week intervals was as shown in Table 3.

Table 3. Effect of digging date on percentage corm rot.

Date Dug:	Sept. 24	Oct. 8	Oct. 22	Nov. 5	Nov. 26	Dec. 16
Percent Loss:	2.4	2.9	4.5	4.6	14.6	27.6

The rainfall increased and the temperature decreased from September 24 to December 16. A similar test by the writer in 1949 gave the results shown in Table 4.

Timmermans (70), Wade (72), and Hawker (38) also found that early digging resulted in more healthy corms. These results are probably based upon the joint action of temperature and moisture as discussed by McClellan, et al. (54).

Since Botrytis leaf blight requires cool, moist conditions for development, it is usually limited in range in the United States. Such conditions commonly coincide with gladiolus growing along the Oregon and Washington coasts in the fall, in southern California in April and May, and in Florida in the winter. Occasionally they occur elsewhere, sometimes in extreme form.

Serious attacks of corm rot are less common, being restricted usually to the Pacific Coast areas but occasionally occurring elsewhere. The corm rot stage seldom occurs in Florida since temperatures there at digging time are usually high enough to promote rapid curing. Recently some severe losses, particularly to small growers, have occurred in the northeastern States. Perhaps the importance of this disease may have been underestimated in the past because of confusion of symptoms with the common Fusarium rot. Comments at the Cleveland symposium indicate that it rates as the number two gladiolus disease in the United States.

SUSCEPTIBILITY

Commercial growers and scientists have frequently observed and occasionally reported the variation in susceptibility of different gladiolus varieties to leaf blight and corm rot. It seems most appropriate to describe the variation as a degree of susceptibility rather than of resistance, since all varieties can apparently become infected under optimum conditions. Varieties that are

Table 4. Effect of digging date on percentage corm rot and yield.

Digging date	Percent* corms rotted	Total weight harvested	Total No. 1 corms
Sept. 13	8	26.3 lbs	222
20	6	26.5	224
27	30	34.1	309
Oct. 4	77	36.2	359
11	94	35.6	355
18	61	40.7	369
25	98	37.3	344
Nov. 1	99	45.5	426
8	99	41.2	373
15	99	43.0	372

* All corms except those of October 18 placed immediately after digging in a cool room (below 50°) to facilitate rotting. Those of October 18 were accidentally heated at 60° for one week, thus resulting in less rot.

Table 5. Susceptibility of Gladiolus varieties to Botrytis leaf blight.

Most Susceptible

Algonquin	Grand Opera	Miss Wisconsin	Rosemaid
Amulet	Hindenburg's Memory	Myrth	Rose O'Day
Annamae	Intruder	Nana	Rose Red
Autumn Gold	Jules Amott	Nowadays	Rose Morn
Bernece	Junior Miss	Nugget	Rosy Red
California	King Bee	Oriental Pearl	Royal Garnet
Candy Splash	King's Ransom	Pacifica	Ruby Red
Carrara	Lady Boo	Paradise	Sahara
Cherry Jam	Lady Jane	Parma	Seedling 1940 #11
Chief Multnomah	Lancaster	Patty Berg	Snow Princess
Connecticut Yankee	Lidice	Paul Revere	Snowsheen
Corona	Maid of Orleans	Pfitzer's Masterpiece	Surfside
Cover Girl	Manchu	Phoebe	Tecumseh
Discovery	Margaret Fulton	Piccolo	Valedictory
Eglantine	Margo	Pink Charm	Vela
Elizabeth Maier	Marimba	Pink Radiance	Vista Bonita
Errey's Scarlet	Marion Pearl	Prestige	Vredenburg
Essa Marie	Marjorie Decou	Purple Supreme	White Gold
Exemplar	Mary Elizabeth	Rampart	White Satin
Flora Farmer	Maytime	Red Bank	Will Scarlet
Fuchsia Maid	Mercury	Red Plush	Wings of Song
Golden Cup	Minstrel	Regent	Wolverine State
Golden State	Miss Cobbleskill	Rio Rita	Yangtze
Graff Seedling #15	Miss Vermont	Robinson Crusoe	

Least Susceptible

Alchemy	Debutante	Mamie	Sea Foam
Sotearoa	Donna	Marqueeta	Silvery Teton
Barbara Jane	Elegy	Niels M. Jensen	Snow White
Bethlehem	Evenglow	Oregon State	Spotlight
Capsicum	Giant Nymph	Pink Paragon	Sun Spot
Chamouny	Gratitude	R.B.	Susannah
Charmaine	Lavender Ruffles	Red Charm	Truelove
Convoy	Lins Seedling #388	Red Rascal	Valeria
Debonair	Malta	Rhoda	Winston

quite susceptible to the blight are not necessarily equally susceptible to corm rot, and vice versa.

A few years ago Magie released a list (48) of varieties with their susceptibility rating in Florida to the leaf blight stage. In Table 5 are listed the most and the least susceptible varieties, according to him. Recently he stated (51) that no variety has been consistently resistant to floret infection.

Timmermans (70) reported that Stofmeel listed the following varieties as very susceptible: Picardy, Mimmelstar, Poolijs, Betty Nuthall, Kassel, Flaming Sword, Roi Saleil, Jacoba van Beieren, and Mount Everest. Less susceptible varieties were Halley, Lilac Wonder, Red Emperor, and l'Immaculée.

Inoculation tests by Moore (57) indicated that Betty Nuthall and Pfitzer's Triumph were more susceptible to core rot than were Yellow Hammer and Halley. He observed severe infection of leaves of Red Emperor but only slight infection of those of Flaming Sword, Lady Boreel, and Halley.

Wade (72) found that Pelegrina, Red Lory, and Miss New Zealand (particularly) were more resistant to corm rot than Golden Goddess, Wolfgang v. Goethe, Gate of Heaven, and Picardy. However, Pelegrina suffered considerably from leaf infection, whereas Picardy had the least of all. He also quoted growers' reports that King Lear, Elinora, Mrs. S. A. Errey, Black Opal, Champlain, Don Brodman, and Rose Dawn were resistant.

There are several other rather fragmentary reports in the literature but the ones given above indicate that a variation in susceptibility exists although probably no variety is immune.

CURING OF CORMS

SUBERIZATION AND CORK FORMATION: It is now generally conceded that the curing of freshly-dug corms at warm temperatures reduces corm rots. Such curing results in formation of suberin layers and cork cells which, in effect, wall off invading fungi such as Botrytis. Before discussing experiments dealing primarily with the control of the fungus, it seems advisable to review pertinent literature primarily concerning the host.

Artschwager and Starrett (4) studied the rate of suberization and wound periderm formation in cut sections of gladiolus (variety Maiden Blush). Tests were initiated on January 6 and samples were taken daily for the first ten days, then on the fifteenth and again on the twenty-second day. The date of digging and previous storage conditions were described. They found (Fig. 7 adapted from their Fig. 6) that: "At sufficiently high relative humidities the suberization process in the gladiolus goes on normally, beginning in the outermost layer of the corm... and extending centripetally to a depth which is related to the storage temperature and the time of differentiation of the first periderm cells. At the lower relative humidities certain peculiarities were observed. ...At the relative humidity of 75 per cent and a temperature of [54° F.] the outermost layer of cells on the exposed surface remained unchanged. Suberization was only evident below the second or third surface layer. At progressively lower relative humidities the failure of the surface cells to suberize became more marked, and in a lot stored at the relative humidity of 61 per cent and a temperature of [83° F.] as many as four or five layers of cells... did not change so that the suberized zone was more or less buried in the tissue. A similar but even more striking case of 'internal' suberization was observed in certain lots stored at relatively low temperatures for a period of 79 days. The relative humidities and the temperatures at which this experiment was carried out, as well as the results obtained, are shown [in Table 6, which gives the data for only one variety from their Table 1]. It will be seen that the nonsuberized layer was in many instances over 10 cells thick... The low temperature [40° F.], although associated with a fairly humid atmosphere [95 percent relative humidity], probably will account for the great thickness of the nonsuberized layer, which must have dried out somewhat or become otherwise changed before suberization took place."

In regard to wound-periderm they (4) found that "Above 80 per cent, differences in relative humidity neither hastened nor slowed up periderm formation; but below 80 per cent, decrease in relative humidity is shown to have had a retarding influence. The effect of relatively low temperatures on wound-periderm formation is prominent [Table 6]. In a previous section it [was] shown that periderm did not develop at temperatures below [60° F] even after a period of 22 days, so that it might have been concluded that wound-periderm formation was completely inhibited at these temperatures. However, when observations were made after a period of 79 days, it was found that this supposition was only partly true and that a broad wound periderm

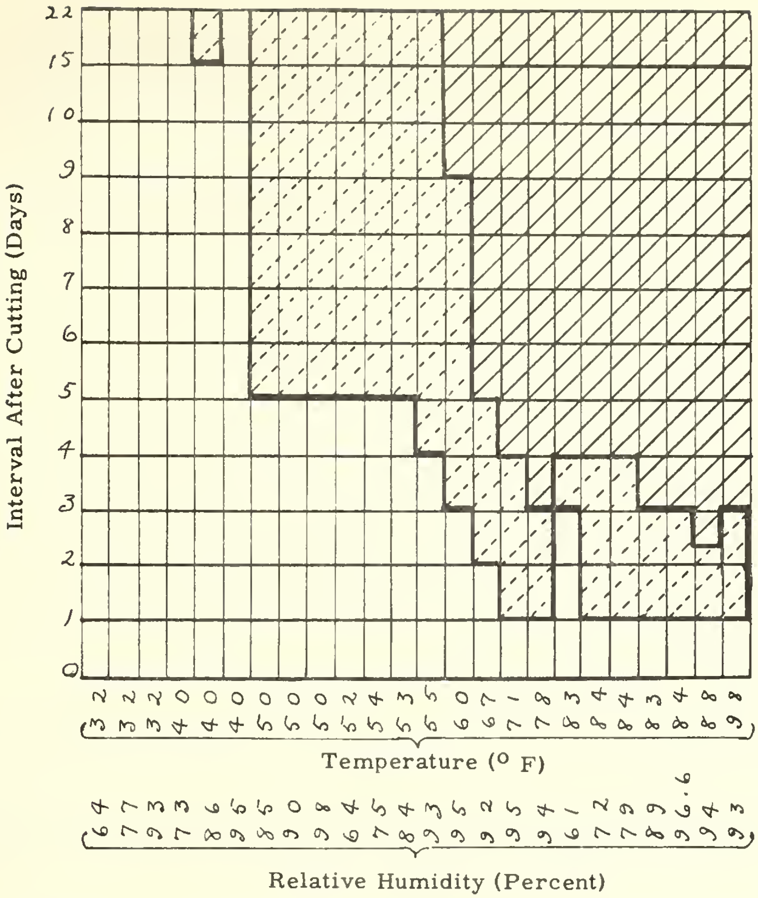

FIGURE 7. Suberization (dotted) and wound-periderm (shaded) formation in gladiolus (Maiden's Blush), January, 1929. (After Fig. 6 from Artschwager and Starrett (4)).

Table 6. Effect of temperature and humidity upon suberization and wound-periderm development in the gladiolus corm (Maiden's Blush). March 1929, 79 days after wounding. (Table 1 from Artschwager and Starrett, (4)).

Temperature	Relative humidity	Thickness of unchanged surface (No. of cell layers)	Thickness of suberized layer (No. of cell layers)	Wound cork
50^{o} F.	85%	6	6	Broad
50^{o} F.	90	2	4	Very broad
50^{o} F.	98	1	6	Very broad
40^{o} F.	73%	20	8	Narrow
40^{o} F.	86	16	8	Narrow
40^{o} F.	95	5	6	Narrow

would develop at [50°] and at [40°] if given sufficient time."

Simmons (67) has recently published a summary of some of his experiments. He found that varieties differ in their formation of cork layers. Some of his comments are: "The importance of this reaction (cork formation) in the curing process, particularly where extensive mechanical injury may occur, is evident. To date inoculation and simple wound studies suggest that it is a natural wound response on the part of the corm and that the fungus exerts little or no influence on it.

"The influence of environmental humidity on wound response of corms of Margaret Beaton and Picardy was investigated. Corms were wounded and subjected to relative humidities of 50%, 75%, and 100%. The temperature was maintained at 85 degrees. The following observations were made:

"(a) Suberization begins at the wounded surface as early as 14 hours after wounding.

"(b) Complete layers of suberized tissue are developed at 48 hours.

"(c) Periderm or cork cells begin to appear below the suberized cells after 3 days and complete cork layers, 1-3 cells deep, develop by the 4th day.

"(d) Both suberization and periderm formation were somewhat retarded at lower relative humidities (50%).

"(e) Corms of Picardy lagged behind those of Margaret Beaton up to at least the 7th day. After this their responses were somewhat erratic and periderm development in Picardy was slower throughout, particularly at 100% relative humidity.

"Observations on stained sections from the inoculated corms showed that at temperatures above 45 degrees a periderm or cork barrier developed and this barrier is probably responsible for the slowing down of the rate of parasitic progress in the corm."

Timmermans (70) stated that the cork layer can be 8 to 10 cells thick. "The hollow corms may also have a cork layer separating the sound from the infected tissue; even the brown vascular bundles are surrounded by corky tissue, contrasting with sound bundles."

RESPIRATION: Whiteman (77) studied "...the relative influence of different storage temperatures on the curing of gladiolus corms as measured by respiration [assuming] that when suberization is well advanced physiological activity is so reduced that the corms may be considered 'cured' and in a resting stage."

He used corms grown near Washington, D. C., dug on October 20 with the tops cut back to 1 1/2 inch and placed in storage October 23. The temperatures used and approximate relative humidities are listed in Table 7.

Table 7. Respiration of corms stored at different temperatures (from Whiteman (77)).

Temperature	Approximate relative humidity	Average respiration in mg. CO_2/kg/hour in milligrams for first two days of curing (4th and 5th day after digging	Respiration in mg. CO_2/kg/hour from 5th to 10th days
32° F.	85%	24	Slowly decreased to about 20
36°	85	29	Slowly decreased to about 23
40°	70	32	Slowly decreased to about 26
50°	75	51	Levelled off near 45 after 5th day
60°	50	81	Slight rise and then rapid drop to 50
70°	40	81	Rapidly decreased to about 46
80°	40	117	Rapidly decreased to about 52

In the first series the corms were cleaned immediately after digging, left in common storage for the next three days, then placed in the various storage chambers. Respiration determinations were made daily for six days. Part of his data are given in Table 7.

As the temperature increased the respiration likewise increased. However, there was a rapid drop within the six-day period, although even at the conclusion of the test the respiration

at high temperatures was approximately double that at low temperatures. The decreased rate was thought to have been due to the advancement of curing or suberization.

In another series, similar corms and storages were used but the corms were not cleaned until November 3 (14 days after digging). The respiration was checked daily from November 5 to November 11 (16th to 22nd day after digging). This, in a sense, was a continuation of the preceding test, with the main difference being the later cleaning of the corms. The respiration rate at the beginning (16th day) was somewhat higher for corms stored at low temperatures than that at the end of the first set, perhaps due to a slight wounding effect in cleaning. (It was noted that corms stored at 50° F and below were difficult to clean on November 3, while others, particularly at 70° and 80°, cleaned easily.) The rate ranged from 20 mg. at 32° to 44 mg. at 80°. By the 22nd day the range was 17 mg. to 24 mg. Although the rate of the high temperature sets had dropped, those of the lower temperatures remained approximately at the same level between the 16th and 22nd days.

In a third series, samples of corms similar to those in the second series were held at the above temperatures until November 30th, then the stems were cut back close to the corms and all were placed at 70° F. A respiration test was started the next day and continued for six days (41st to 46th day after digging). The sets previously stored at 32°, 36°, and 40° F respired very rapidly, in fact even more rapidly than the set in the first experiment stored at 70° three days after digging. The rate for these sets (32°, 36°, and 40°) fell off rapidly to between 39 and 56 mg. on the 46th day. The rate for the 60°, 70°, and 80° F sets remained approximately the same (14 to 26 mg.) throughout the test. Whiteman suggests that the unusually high rate for the low temperature sets may have been due to insufficient suberization, wounding effect, freer exchange of gases through cut stems, or oxidation of accumulated hexose sugars. The rapid decline in respiration of these sets after the first day may have been due to a reversion of sugars to starch.

In another smaller test by Whiteman, the respiration rate was determined for corms that had been dug October 20 and held from October 23 to November 20 at 80° F (cleaned on November 3). One set was left intact. In the other set, all scales and stems were removed. Respiration (which was measured from November 20 to 26) began at 18 mg. and ended at 22 mg. for the intact set; with corresponding figures of 59 and 20 mg. for the other set. As Whiteman stated, "It can hardly be doubted that these corms were cured after 31 days at 80°." He suggested that the increased respiration may have been due to either wound stimulation (by removing scales and stems), or to a freer interchange of gases, or to both.

In an additional small test similar corms held at 70° F from October 23 to December 7 (cleaned November 3) were moved to 32°. The respiration for the next two days averaged 2.3 mg.. On December 10 the corms were returned to 70° F. The respiration rate was 41 mg. on December 11th and 24 mg. on December 12th. The rate of 41 mg. was practically double the rate at 70° at the end of the second experiment.

Denny (26) found that corms stored for a long period in moist soil near 81° F remain dormant but exhibit an unusual type of respiration when removed. "When first removed from the soil after a sojourn in it of several or even a few months, the carbon dioxide production at the temperature which prevailed during the storage in soil is very low, approximately 2 to 10 mg. CO_2 per kg. per hour. This low rate is maintained, however, for only 4 to 8 hours, when the rate rises rapidly until within 24 to 48 hours it reaches 20, 40, 80 or even more than 100 mg. From this maximum the respiration curve falls gradually until after 5 to 7 days the original low rate is reached, this being maintained indefinitely. In spite of this great change in respiratory activity the rest period is not broken, but these corms retain their dormancy, may be again planted in soil and become available for another respiration test. The curve is again given by a subsequent test, provided the period in the soil following the first removal is approximately three months. During the first few hours after removal from the soil (when the rate is low and rising) the volume of oxygen taken in is much larger than the volume of carbon dioxide given off, approximately two to three times as large; but at the time of the maximum rate, and in the entire period during the falling rate, even to the time of the secondary minimum, the volumes of O_2 and CO_2 are equal."

Additional data on respiration and gas (CO_2 and O_2) content of corms are contained in an article by Thornton and Denny (69), and similar corroborative data for breaking dormancy in a 1942 publication by Denny (27).

MOISTURE CONTENT AND LOSS: The average moisture content of freshly dug corms was found by Gault[5] to be 72.8 percent. Corms field-dried and held in a shed for two months until ready to be cleaned contained 62.5 percent. Corms cured at 100°, 110°, and 120° F for 96, 97, and 94 hours, respectively, contained 66.2, 64.5, and 56.2 percent water.

Pridham (62) checked the loss in weight at monthly intervals of Lucette corms (1 1/4 inch diameter) stored at 30° and 60° F. His results were as shown in Table 8.

Table 8. Percentage loss in weight of Lucette corms (1932-33) (from Pridham)

Date	Temperature 30°	60°
Dec. 1	6.75	9.20
Jan. 1	6.00	8.56
Feb. 1	10.57	15.89
March 1	10.86	18.01
April 1	11.75	22.39
May 1	19.23	34.16

He suggested that the greater loss in weight at 60°, especially during the last three months of storage, may be due to the production of root initials and apical buds which would result in increased transpiration and respiration.

Cropsey (17) found in drying tests in 1950 at Oregon State College that freshly dug corms (five for each test) lost about 22 percent in weight at 90° F and 50 percent relative humidity within 24 hours, but that it took 72 hours to achieve the same moisture loss at 70° and 50 percent relative humidity. Drying at 90° with relative humidities of 30 and 50 percent resulted in about 35 percent more moisture loss than at 90° with 80 percent relative humidity.

Pommert (60) ran some tests in his warehouse with results as follows: "Recent experiments in our own drying room, using 50 jumbo and No. 1 bulbs of Lady Jane in each lot, indicated that bulbs placed in the direct blast of air with a temperature on the bulbs of 115°, 10% relative humidity (outdoor temperature 66, relative humidity 70%) for 4 hours, had exactly the same weight loss in 4 hours as a like quantity of bulbs dried at 83°, 68% relative humidity, but with accelerated air movement over the second lot of bulbs. The bulbs held for 4 hours at 115° were quite spongy the following day, indicating too much heat, and possibly too low a humidity, rather than too rapid drying. With the 83° temperature as indicated above we can, with freshly dug bulbs, dry and without adhering soil, remove approximately 13.5% moisture, by weight, in 45 hours. If bulbs are wet, or if there is adhering soil, the weight loss will be greater. Our experience indicates that these bulbs are dry enough to go into the storage warehouse provided there is some heat in storage and plenty of circulation and ventilation."

In a recent article Magie (52) has stated that: "Experiments indicate that too rapid drying results in reduction of flower yield, especially with immature bulbs. With rapid movement of air around the bulbs, the temperature should be under 85° F., possibly under 80°. Temperatures over 90° F. should be avoided. The bulbs should not lose more than 20 percent of their weight in moisture during 5 to 7 days of warm curing, according to tests with Picardy variety. Perhaps 20 percent is too high. Rate of moisture loss varies with maturity of bulb, the variety and out-door temperature." He stated in a letter to the writer (February 13, 1953) that he prefers a curing temperature below 90° in Florida because the heating of fresh air to 90° or above would usually result in an excessively low humidity.

Emsweller (32) ran a series of storage tests in 1929/30 at Davis, California. Corms (Prince of Wales variety), about 3/4 inch in diameter, were dug in late October, cleaned and placed in storage on November 6. The percentage loss in weight from November 6 to March 15 was 6 at 38°, 10 at 46°, 12 at 54°, and 20 at 86° F. Corms stored at 86° were somewhat dessicated by February 15 and by March 15 they had sprouted. At intervals Emsweller (32) planted samples of 50 corms each that had been stored at the temperatures listed above. In each

[5] Gault, Ray. (Northern Illinois Public Service Co.). Typed report of 1948/49 experiments made available by Mr. Ralph Pommert, Pacific, Washington.

planting flower production began first from corms stored at 86°. The first series (stored at 86° and planted December 20) began blooming on April 29 and 78 percent of the plants had bloomed by May 13 when the first flower of the comparable 54° set appeared. The second series (86° and January 24 planting) began blooming May 6 and was 98 percent completed by the time (May 19) the first flower of the 54° set appeared. The earliness of the 86° sets persisted even into the last planting series (March 15), but the flowers were fewer and poorer. Only corms of this series that had been stored at 38° gave 100 percent production of good quality flowers. The spikes of all lots except the 46°, 54°, and 86° of the last planting were of high quality. Part of his data on blooming and corm production are contained in Table 9.

Table 9. Effect of storage temperature and time of planting on number of days until first bloom and weight of corms harvested.

Time of planting	Days to first bloom				Weight (grams) of new corms harvested			
	38°	46°	54°	86°	38°	46°	54°	86°
Dec. 20	150	148	144	130	3610	3466	3588	3315
Jan. 24	121	120	115	102	3242	2977	3242	3062
Feb. 15	122	130	117	106	3776	3807	3261	2999
March. 15	112	112	107	102	3670	2410	1979	1743

With freshly dug corms, Forsberg (35) in Illinois reported that adequate drying (as determined by feeling) was accomplished in 16 hours or less (depending upon moisture, etc.) at temperatures of 82° to 104° F. Corms kept well and flowered normally. Forsberg's observations indicated that general warehouse curing was not successful. He adapted a portable forage drier for his large scale tests.

A. N. Roberts of Oregon State College ran curing tests a few years ago, using a small portable prune and nut drier with forced air circulation. He tried 90° F. for 10, 20, 30, and 40 hours; 100° for 7, 14, 20, and 30 hours; and 122° for 7, 10, 13, and 16 hours. He summarized his results as follows in a recent letter (December 22, 1952) to the writer:

"All bulbs, regardless of time factor, dried at 122 degrees F. were cooked or excessively discolored. We were trying for a quick surface moisture removal to save time, but it just does not work that way. It is apparent that some time is needed for certain cell changes, etc.

"In the 100 degrees F. series seven hours and fourteen hours did not give sufficient time to remove sufficient moisture for good cleaning immediately after. However, at both twenty hours and thirty hours, particularly the latter, the bulbs came out in excellent condition, and could have the roots removed right from the drier. The bulbs grew excellently the following year.

"In the 90 degrees F. series, ten hours was not long enough for curing, it was not possible to snap off the root cap. At twenty hours they cleaned nicely as was also the case for thirty hours hours at 90 degrees F. However, the forty hour treatment, while not showing injury, was a little too dry for good cleaning. All this series had excellent appearance and grew well the following year.

"The drying we refer to above is the surface husks, etc., and does not indicate any excessive drying of the bulb itself. The only injury experienced was at 122 degrees F. Of course, there is quite a spread between 100 degrees F. and 122 degrees F. but a temperature of 90 degrees F. was very good as was 100 degrees F., showing a safe spread of temperature in these experiments."

Bald (9) found that corms cured at 95° F were ready to clean within six to seven days, whereas about three weeks were needed at 65° and over six weeks at 55°.

In Gault's[6] experiments corms cured at 100° F for 2, 4, 8, 24, 54, 72, and 96 hours, with relative humidity between 19 and 21 percent, grew well. Those held at 110° for 4, 8, 16, and 24 hours (R.H. 10 to 16 percent) grew well, but the 53 and 97 hour sets (R.H. 13 and 14 percent) were injured. Corms cured at 120° for 2, 4, and 8 hours (R.H. 11 or 12 percent) grew well; for 16 hours (R.H. 12 percent) gave weak growth; while those held for 24, 52, and 94 hours (R.H.

[6] Gault, Ray. op. cit.

14 to 21 percent) did not grow.

Bald (9) stated that curing at 85° F. of corms grown and dug in cool weather encouraged an immediate growth of root initials and buds, which was sometimes prevented by a 95° curing.

In connection with his experiments Simmons (67) stated that, "The use of high temperatures for short periods to speed up curing, now practiced by many large growers, prompted a study of possible effect of high temperature on subsequent behavior of the corm.

"The most striking result of applying dry heat to freshly dug corms appeared to be a tendency to break dormancy. A duplicate trial on old cured corms showed that such corms would withstand quite high temperatures and still sprout. Of those exposed to as high a temperature as 135 degrees for 15 minutes 90% produced shoots."

The writer ran two tests in 1947/48 on the effect of curing on flowering. In the first test corms were dug November 11 and 12 and left in cool storage until November 15, when they were cured for 1, 2, 4, 6, 8, or 10 days at 80° F, returned to cool storage and later planted in the field. Three hundred Surfside and 200 Rosa Van Lima corms (mixed small sizes) were used per treatment. None of the curing treatments affected either earliness of flowering or total number of flowers.

In the other experiment, Picardy corms were dug December 11, washed, cured for 10 hours at 80°, 90°, 100°, 110°, 120°, or 130° F, then stored in a cool (about 50°) room, examined February 7, and planted March 29 and 30. Five hundred corms of mixed small sizes were used per treatment. None of these treatments affected the earliness of flowering or the total production of flowers.

After experiments to accelerate forcing, Loomis (44) came to the conclusion that: "In general, storage treatments of 1 week at 104° F., 2 weeks at 95° F., 4 weeks at 86° F., 6 weeks at 77° F., or 8 to 10 weeks at 68° F. have been approximately equal in their effectiveness on recently dug corms. The lower temperatures with the longer exposures are safer, and milder temperatures should be used for corms already partly through the rest period." Although he does not indicate the digging date, the treating was begun October 28, November 14, or November 17.

EFFECT OF CURING TEMPERATURE ON CONTROL OF CORM ROT: Cropsey (16) found that the loss from rot was greater in corms dried at 65° to 70° for 20 days than in those dried at 95° F for 23 hours, but the amount of rot was small in both cases (4.5 vs. 3.5 percent). Washing and/or turning the corms helped reduce the loss to 1.7 percent or lower in the 95° test.

In a copy of a letter sent the writer in 1951, Cropsey stated that he had obtained best results by curing at 80° to 90° F. from 48 to 72 hours with a relative humidity between 50 to 80 percent using air velocities up to 200 feet per minute, 3 or 4 air changes per hour, turning the corms in order to insure uniform drying and subsequently storing at 50°.

Gould (36) obtained a decrease in Botrytis rot in 1947 by curing J. S. Back corms for 48 hours immediately after digging, as shown in Table 10.

Table 10. Effect of curing treatment on corm rot.

Treatment	Percent of rotted corms
Uncured	18.5
Cured at 75° F	2.0
85°	0.25
95°	0.25

The writer ran several other curing experiments in 1947, in some of which the corms were planted in the field to obtain data on flower and corm yields. The results given in Table 11 indicate that curing for even 12 hours at 75° F decreased the loss from rot, although the amount was unusually low.

In the experiments by the writer in 1947 described in the previous section, corm rot was negligible in the first test. However, in the second the percentage loss was: 20.0 in uncured; 11.4 at 80° F; 14.6 at 90°; 17.2 at 100°; 27.4 at 110°; 23.4 at 120°; and 22.8 at 130°. The loss was reduced at 80° and 90°, but increased at temperatures above 100°. This may have been caused by heat injury.

Bald (13) stated that the fungus remains alive in corm lesions arrested by curing at 95° F.

Table 11. Effect of curing treatment on corm rot.

Variety	Ethel Cave Cole	Beacon	J. S. Bach
Date dug	Probably Oct. 24	Oct. 14	Oct. 23
Began curing	Oct. 25	Oct. 15	Oct. 23
Later storage	Commercial (40-60°)	Comm. (40-60°)	Comm. (40-60°)
Examined	Jan. 13	Jan. 14	Jan. 14
Number of corms per treatment	500	500	400
No. hours cured	27 1/2	See below	See below
Treatment :	Percentage of rotted corms		
Uncured	1.6	7.0	18.5
Cured at 75°	0.2	12 hrs : 4.0	24 hrs : 1.5
		24 hrs : 5.2	48 hrs : 2.0
Cured at 85°	0.6	12 hrs : 2.4	24 hrs : 0.8
		24 hrs : 2.8	48 hrs : 0.2
Cured at 95°	0.4	12 hrs : 4.4	24 hrs : 5.5
		24 hrs : 3.4	48 hrs. : 0.2

EFFECT OF WASHING CORMS BEFORE CURING: Hawker (38) did not reduce rot by washing bulbs lifted from wet ground. The writer studied the effect of washing in two experiments in 1947. In the first Picardy corms from plants heavily infected with Botrytis in the Experiment Station plots were dug on November 11, separated into lots of 1000, treated on November 11, stored at approximately 60° F, and checked January 20. Treatment and results are shown in Table 12.

Table 12. Effect of curing and washing on corm rot.

Treatment	Percentage of rotted corms	Condition of corms after curing
Uncured and unwashed	2.5	---
Cured at 90° F (24 hrs) unwashed	0.8	Slightly spongy
Cured at 90° F (24hrs) washed	1.0	Quite spongy

In another test Picardy corms (mixed small sizes from plants heavily infected with Botrytis), dug and supplied by a commercial grower on November 12 were treated immediately, stored afterwards at about 50° to 60° F, and checked January 20 (Table 13).

None of the corms in this test appeared as dessicated as those cured at 90° F in the experiment previously described. These results would suggest that corm condition (water content--?), as well as temperature, play a part in the so-called heat injury.

PREVIOUS RECOMMENDATIONS FOR CURING: Drayton (31) suggested curing at 55° to 60° F and then storing at 40°. Donk and Roggeveen (30) in Holland recommended four to eight days at 80° to 90°, and storage in a well-ventilated barn at ± 60°. Other Dutch (1) recommendations are for curing at 70° to 80° in dry years or with partially dried corms, and 85° to 95° otherwise.

McCulloch and Weigel (55)recommended, for control of Penicillium rot, curing for a week or more at 80 to 90° F immediately after digging and subsequent storage at 35 to 45° with good ventilation and a dry atmosphere.

Crossley and Arrowsmith (19) suggest curing at 75° to 80° F for 10 to 14 days with adequate ventilation, followed by storage at 40° (range of 38° to 45° regarded as satisfactory). They also suggest raising the temperature periodically for a day or two to evaporate accumulated moisture.

Table 13. Effect of curing and washing on corm rot and flowering.

Treatment (500 corms per treatment)		Length of curing (hrs.)	Percentage of rotted* corms	No. flowers by July 10	Total no. flowers
Uncured,	Unwashed	None	3.8	37	51
	Washed	None	1.8	39	51
Washed, dipped in Tersan		None	1.2	27	42
Cured at 80° F,	Washed	41	0.6	40	53
	Unwashed	41	0.6	37	47
Cured at 100° F,	Washed	22	1.4	23	39
	Unwashed	22	1.4	18	36
Cured at 120° F,	Washed	10	5.4	32	50
	Unwashed	10	4.0	34	47

* All types of rot, including heat injury at 120° (turning brown or black) subsequently followed with blue mold.

Bald (12) recommends curing corms immediately after digging in southern California for six to ten days at 95° F with a relative humidity near 80 percent (around corms) and good air movement. After cleaning corms should be replaced at 95° for four to seven days in order to heal wounds, before storing at 40° in a relative humidity between 70 and 80 percent.

STORAGE FOLLOWING CURING: Post (61) stated that "...storage of corms at 40° after curing and cleaning is standard practice among growers. Corms held at this temperature for 60 to 90 days grow rapidly when they are planted. The relative humidity is maintained at 75 to 80 percent with the air circulating freely. ...Storage at 80 to 90° F. for one month before planting is common among greenhouse operators." Yerkes (79) suggested storage at 40° to 45° F. Chase (14) in Florida stated that outdoor curing followed by storage at 38° to 40° was best under their conditions. Grove (37) in Iowa suggested curing in a warm room and then storing at 40° (range of 32° to 50°) and 75 percent humidity.

Rose _et al_. (64) stated that gladiolus ...may be stored at 40° to 50° with a relative humidity of 70 to 75 percent for 7 to 8 months. A temperature of 40° will hold these corms dormant during the normal storage season, whereas at 50° sprouting will occur after 4 to 6 months storage. They should be stored dry in shallow trays with ample ventilation but only after a curing period of 3 to 6 weeks in an open or well-ventilated shed."

Fairburn (33) found that storage of corms (variety Giant Nymph) from October 18 to February 8 at 50°, 70°, and 90° F resulted in 4.2, 5.2, and 15.7 percent loss in weight, respectively. Corms stored in an open tray in a laboratory at 77° for 200 days lost 32 percent, of which 55 percent occurred within the first three weeks after harvesting. Giant Nymph glads were dried for three days at 77°, transferred to 50° until December 8, and then stored at 32°, 41°, and 50° until planting on May 8. Corms held at 50° produced the most spikes, earliest flowers, and greatest number of new corms. He also found that higher temperatures (up to 90°) produced excellent early spikes under greenhouse forcing conditions, but indicated that the results did not necessarily apply to the field.

Fairburn also found that an early flowering variety (Souvenir) respired more rapidly than did a late one (Giant Nymph) and suggested that optimum storage temperatures for the two might be different. For instance, early varieties would be benefited by moderately low storage temperatures to reduce the combustion rate of plant foods, whereas late maturing varieties might benefit from higher temperatures that would increase the respiration rate and shorten the dormant period.

Pridham and Ratsek (63) made a rather thorough study of storage temperatures as they affect flowering and corm yield. They used several varieties, but the most common one was Lucette. Corms were harvested from October to November 15, dried, cleaned, and placed in storage in November. Five sizes were used, as indicated in Table 14. For the 1 1/4 inch size,

Table 14. Experiments with the variety Lucette (from Pridham and Ratsek).

Storage temperature (°F)	Corm diameter (inches) 1.25	1.00	0.75	0.50	0.25	High Humidity 1.25	Low Humidity 1.25
	Percentage Weight Loss by Corms in Storage (November-April)						
32[a]	14.82	19.93	23.45	27.57	30.44	6.00	26.00
40	10.46	14.84	16.36	18.84	21.62	5.00	27.00
50	18.67	27.35	28.08	27.24	27.88	4.00	30.00
60	26.62	25.10	26.69	26.39	32.69	13.90	33.33
70	38.63	34.02	28.27	31.96	36.18	---	47.00
	Number of Days from Planting to Bloom						
32	115.2	113.2	112.3	113.7	119.9	114.0	118.7
40	112.8	110.0	110.8	111.5	115.9	108.2	113.1
50	111.4	107.8	109.3	111.2	118.3	105.7	109.8
60	108.0	113.3	116.3	116.4	120.0	112.7	107.5
70	108.3	101.9	101.5	111.7	120.4	82.2	107.5
	Number of Flower Spikes per Corm Planted						
32	1.80	1.36	0.95	0.85	0.68	1.23	1.55
40	1.75	0.95	0.99	0.93	0.92	1.13	1.05
50	1.38	0.99	0.96	0.97	0.83	1.05	1.30
60	1.10	1.03	0.95	0.94	0.59	0.98	1.13
70	1.13	1.06	0.83	0.93	0.92	0.55	0.30
	Number of Corms Harvested per Corm Planted						
32	2.10	1.481	0.98	0.88	0.73	1.40	1.72
40	1.80	0.980	1.02	0.97	0.97	1.15	1.20
50	1.53	1.104	0.99	0.96	0.87	1.05	1.37
60	1.38	1.040	0.99	0.97	0.66	1.15	1.20
70	1.35	1.286	0.96	0.81	0.86	0.70	0.75
	Yield of Corms as Percentage of Weight of Corms Planted						
32	156.5	230.1	278.2	428.3	694.0	148.8	192.8
40	200.0	197.9	367.6	534.8	1066.2	136.3	215.8
50	145.5	200.2	307.6	473.1	967.0	123.9	200.2
60	167.5	206.9	319.1	472.2	723.5	154.9	210.0
70	183.8	289.6	409.6	642.9	1289.8	151.5	117.5

[a] 30° is listed in the reference (63) but the refrigerator was actually set at 32° according to a letter (September 25, 1953) from Pridham.

four samples of 10 corms each were used; for 1 inch, 3/4 inch and 1/2 inch, ten samples of 25 corms each; and for 1/4 inch, four samples of 25 corms each. Humidity trials were made also with the largest corms, with one sample suspended over water (near 100 percent relative humidity) and the other over calcium chloride (about 10 percent relative humidity), both in closed containers. The average temperatures and relative humidities were: 32° F., 70 percent; 40°, 80 percent; 50°, 50 percent; 60°, 60 percent; 70°, 30 percent. The corms were removed from storage on April 15, weighed and examined, planted in pots and grown in the greenhouse for one month, then transplanted into the field. Plants were dug October 1, dried for a week, then cleaned, counted and weighed. Data for the variety Lucette are contained in Table 14.

The results seem to be more consistent with the largest corms than with the smaller ones. With the former the percentage of weight loss was least at the low temperatures and increased as the temperature rose to 70° F; the number of days to bloom, the number of flower spikes per corm, and the number of corms harvested per corm planted decreased as the temperature increased; yield of corms as a percentage of weight of corms planted had two peaks, one at 40° and the next highest at 70°. The detrimental effect of low humidity was more noticeable at high than at low temperatures on loss of corm weight.

In additional tests with nine other varieties, Pridham (62) found that the large corms gave more consistent results than did small ones. Low temperature storage induced delay in flowering but resulted in maximum flower spike production.

Ryan and Ulman (65) stated that at the University of California at Los Angeles, "A doctoral dissertation by George F. Ryan reported that the rest period of deeply resting corms was prolonged in some cases (but not all) by exposure to high temperatures (95° F.) either during a curing period or during storage. Corms stored at 34 to 39° F. had a considerably shorter rest period than corms stored at 70 to 95° F. Brief exposure to the latter temperature did not interfere with the rest-breaking influence of the low temperature. Corms which reached maturity with soil temperatures above 59° F. had a somewhat more profound rest than corms which were exposed to temperatures of 50° F. for the equivalent of several days during the final weeks before harvest."

Lauritzen and Wright (43) ran storage tests in three different years, using several varieties at different temperatures and ranges of relative humidity including: 32° F. (64 to 93 percent R.H.); 40° (72 to 95 percent); and 50° (81 to 98 percent). In general they found that the lower the humidity the greater the weight loss. Surprisingly enough they obtained more loss at 32° than at 40°, presumably owing to the lack of suberization at the lower temperature. Most corms remained dormant at 32°, at 40° some rooting was present, while at 50° both sprouting and rooting were common, particularly at the higher humidities. The average (of three humidities) moisture loss was 8.2 percent at 32°, 7 percent at 40°, and 8.2 percent at 50°. There was considerable difference in weight loss among the different varieties. In general the total corm yield increased as the storage temperature dropped from 50° to 40° to 32°, but the largest yield of #1 corms was often greatest near 40° F. The optimum humidity at this temperature varied for corm yield with the variety. Similar tests showed that the different humidities did not seem to affect flower production nor the total germination. Data given for 1928-29 indicated that storage near 32° retarded emergence. In connection with studies on infection by Penicillium gladioli, they decided that temperature was more important than humidity in limiting or promoting suberization and periderm formation.

Weinard and Decker (73) reported an experiment by Floyd in which "...gladiolus corms were stored in an open shed in Florida and also placed for periods as long as four months in cold storage at 32° to 35° F. and at 42° to 45° F. before planting in the field. Corms stored at 32° to 35° F. came up and also bloomed about a week later than did corms stored at 42° to 45° F. The length of time the corms were in cold storage seemed to make little difference in the results. There was no marked difference in results with corms stored at 42° to 45° F. as compared with corms stored in the open air."

Weinard and Decker (73) stored corms in 1925 for 9 to 13 weeks at 38° and 70° to 80° F, then forced them in a greenhouse. The corms from warm storage sprouted 5 to 18 days sooner than those from cold storage and flowered slightly earlier, but the percentage of corms flowering was inconsistent.

Magie (52) made the following comments in 1952: "In a test comparing 92 percent with 70 percent relative humidity in 40° F. storages, there was little difference in results with Picardy or Snow Princess bulbs, except that immature bulbs produced better flowers after storage at 92 percent humidity. The lower humidity favored flowering of mature Snow Princess bulbs and increased the number of sprouts that grew from each bulb. Storage humidity probably has a minor effect on bulbs, provided it is not so low as to cause excessive water loss or high enough to

cause root growth. The evidence at hand indicates a relative humidity of 80-85 percent is best for 40° storage if the temperature does not fluctuate and moisture does not collect on bulbs. At higher temperatures, lower humidities may be necessary to avoid sprouting."

Lauritzen and Wright (43) obtained no particular difference in emergence or flowering of corms stored at 40° F from November 18 to March 17, then placed at temperatures ranging from 54° to 99° F for ten days, and next forced in a greenhouse.

Denny and Miller (22) found that low storage temperatures (37° and 50°F) were more effective in shortening the rest period than were higher temperatures (64° to 77°, 84°, or 95°) for periods of 28 to 97 days. Denny (23) obtained much earlier germination in all varieties tested with corms placed for six weeks at 37° and 50° ten days after harvest than with those stored at 86° and 95°. With corms held at room temperature (about 72°) for 52 days before being placed in storage, the temperature effect varied with the variety, low temperatures being optimum for such varieties as Dr. F. E. Bennett and high temperatures for Souvenir. Samples of 18 to 35 corms were used in these tests.

Denny (26) summarized the results of additional studies (24, 25) on respiration and rest periods as follows in 1940: "Although gladiolus corms when freshly harvested are dormant, they pass through this rest period, usually in one to three months, and then will germinate promptly when planted. This rest period may be prolonged for many months or for two years or more with certain varieties by the simple expedient of replanting the freshly harvested corms in moist soil and storing at room temperature or preferably at about 81° F. With the passage of time, corms with a rest period artifically prolonged in this way become sensitive to low temperatures, such as 32° and 41° F. Germination can then be induced by short periods of chilling such as 48, 24, 12 or even 6 hours, depending on the variety and the duration of the period of enforced rest at the time of the exposure to cold."

EFFECT OF STORAGE ON DISEASE CONTROL: Cropsey (17) inoculated corms of Picardy with Botrytis and Fusarium, held them for 48 hours at 58° F and 98 percent relative humidity, next cured them at 95° for 24 hours, and then placed samples in storage at 40°, 50°, or 60° from October 16 to March 22. The total loss from rot was as shown in Table 15. He concluded

Table 15. Percentage loss from corm rot (from Cropsey)

Inoculated with	Loss (percent) at indicated storage temperature (° F)		
	40	50	60
Botrytis	76	24	54
Fusarium	27	86	99
None	1	11	16

that 50° was the best all-round temperature. Although no comparable checks were made at common storage temperatures, it would appear from a comparison of inoculated and noninoculated data that 24 hours at 95° did not provide adequate curing. The high loss from Botrytis at 60° is also interesting in view of tests by others, which would indicate that this temperature should be too high for much infection to occur.

VENTILATION IN STORAGE: Magie (52) has stressed the need of proper ventilation in storage, particularly with freshly-dug corms. "Bulbs have been killed by lack of aeration in storage. Usually the injury caused by confinement shows up as a white pitting or chalky pit. White, chalky tissue also develops at the site of bruises if ventilation is poor. Other symptoms of poor aeration are scald of bulb surfaces, blackening of root traces, multiple sprouting, and activation of latent Fusarium infections after planting. There have been several clear-cut cases of severe losses from Fusarium brown rot, in resistant as well as susceptible varieties, as a result of accumulation of toxic gaseous by-products from physiologically active bulbs in transit or in storage that became warm and moist. Many instances of shipped bulbs rotting badly after being planted by the customer can be explained by improper ventilation in curing or shipment of bulbs."

CURING: Warm temperature curing, regardless of whether it is performed under natural or artifical conditions, results in a number of more or less related changes in the corm. First, and most obvious, is the loss of water; second is the deposition of suberin in one or more layers of cells; third is the formation of cork layers around wounds, etc. and the abscission layer at the base of the new corm; and fourth are various other physiological processes as shown by respiration tests. (The formation of the abscission layer at the base of the new corm cuts off the old one, prevents excessive drying and retards fungus invasion.)

When harvesting is done during warm weather such as usually occurs in the Midwest, Florida, and similar areas, normal temperatures should promote adequate curing. However, artificial curing must be resorted to under cool moist conditions such as normally occur in the Pacific Northwest and often elsewhere.

The few pertinent tests that have been made indicate that curing should begin soon after digging. From available data it appears that a temperature range of 85° to 95° F should be optimum, but the condition of the corm should probably dictate the choice of temperature. Higher temperatures may result in more rapid curing but may also result in heat injury, especially to immature corms. The humidity is also very important and some of the injury previously encountered at temperatures such as 90° to 95° may be due to excessively low humidity. The relative humidity apparently should be about 80 percent around the corms. Between stacks of trays it may be lower.

The practical application should not be overlooked. For instance, Pommert (60) has come to the conclusion, after considering both the cost of fuel and loss from corm rot, that a temperature of 75° to 80° F is the most satisfactory under his conditions.

Some growers have attempted to warm up their entire warehouse for curing purposes. This has not ordinarily been successful. Most growers have used one or more rooms specifically for the purpose. The location of the heater and fan and arrangement of trays should be examined by an agricultural engineer, or the grower should check with an accurate thermometer the temperature in all parts of the room when filled with bulbs, and check the air circulation with a smoke generator. Too often a stratification of air exists with the possibility of the upper corms being overcured and the lower ones undercured.

The small grower often has difficulty obtaining the proper curing conditions. He can sometimes use a furnace room (although it would seldom reach a temperature of 85° F) by putting up temporary partitions, hanging tarpaulins, etc. A fan should always be used in order to circulate air adequately.

Krone (42) made an interesting suggestion for the small grower, namely, the use of infrared heat bulbs as a source of heat. They should be supplemented with a fan.

Thermostatically controlled electric heaters are an excellent possibility for the small grower. The writer has used one type (Thermador, 3000 KW, 220 volts, with the fan bypassed so it runs continuously) for five years in his experiments, with variation in temperature of approximately ± 1.5° F.

In order to maintain the proper temperature and relative humidity, a thermometer and humidity indicator should be kept constantly in the curing room as well as in the warehouse.

<u>When is a corm cured</u>? -- Some workers have suggested that the amount of moisture lost is the best indicator. Although that may be true, it would seem more practical to use the formation of the abscission layer (when the old and new corms separate easily) as the criterion.

Under conditions in western Washington, artificially cured corms can be cleaned sooner than is usually the case, but unless done immediately cleaning becomes increasingly more difficult. This may be made somewhat easier by overnight covering with a damp sack.

Hawker (38) obtained less rot in corms that were cleaned early and completely than in those cleaned more than a month after digging and only partially.

<u>How long to cure</u>? -- This will depend upon the temperature and relative humidity used, condition of corm, number of corms per room, etc. Corms grown under very moist and cool conditions are more "succulent" and probably require a longer time than those grown under drier conditions. Seven to ten days is often sufficient. These more succulent bulbs also may be more susceptible to heat injury.

<u>Curing after cleaning</u>? -- Bald's (9) tests indicate that curing again at 95° F for four days after cleaning facilitates suberin and cork formation in the wounded base, thereby decreasing

opportunity for fungus invasion.

STORAGE: Judging from the available data, there seems to be considerable merit in storage temperatures of either 40° or 50° F, but 40° would seem to be somewhat better. The optimum humidity is still unknown, but the limited data indicate that a relative humidity between 70 and 80 percent may be best.

Even cured corms are constantly losing moisture and accumulation on the surface during storage may permit growth of various fungi. Therfore, the suggestion made by certain workers of raising the temperature periodically in the warehouse in order to evaporate condensed moisture seems logical. The frequency with which this should be done, the optimum temperature to use, and the duration of the heating periods, are problems for investigation.

FUNGICIDAL DISINFECTION OF CORMS: The fungicidal disinfection of corms to control various rots has probably received more attention than any other means of control. Some tests have been made immediately after digging (labelled "pre-curing" below), some after cleaning ("pre-storage") and some just prior to planting ("pre-planting"). The following experiments were particularly concerned with Botrytis control.

Pre-curing -- Hawker (38) reduced the rot slightly in a small scale test by dusting corms immediately after digging with pentachloronitrobenzene.

Wade (72) reduced corm rot from 47.5 percent in the untreated set to 8.4 percent in sets dipped for 15 minutes in Hortosan D.P. (an organic mercury compound) at digging time. Other mercuries including mercuric bichloride were good but not quite so effective.

Pre-storage -- Davidson (20) reported some pre-storage experiments by Davis, who used seven materials on more than 12,000 corms without obtaining any appreciable reduction of rot.

White (76) stated in 1946 that Botrytis rot of corms in Tasmania was effectively controlled by descaling ten days after digging and then treating with tetroc or Spergon.

Hawker (38) reported some unpublished data by Burrows, who obtained a reduction of rot during storage from 23.8 percent to 2.5 percent and 7.0 percent by treating with pentachloronitrobenzene (p.c.n.b.) and Brassisan, respectively. Hawker also obtained promising results with p.c.n.b. but had better control with a 20-minute, 1-hour or 3-hour soak in 0.1% mercuric chloride. The latter did not adversely effect plant growth in 1942 or 1943, but did in 1944.

Bald (12) suggests dusting or dipping with Arasan, Spergon, or some other mild fungicide.

Pre-planting -- In contrast to the benefit from mercuric chloride over p.c.n.b. as a pre-storage treatment was the treatment at planting time, when the p.c.n.b. gave superior results in a small scale test by Hawker (38). She attributed this to the more rapid leaching of mercuric chloride from corms in the soil. The p.c.n.b. did not affect flowering or corm yield.

According to Magie (47) Botrytis corm rot following planting "...was controlled in the Maid of Orleans variety by treating the corms at planting time in a 2 percent suspension of Tersan, in phenyl mercury oleate 1/8 percent, in Ceresan M 1/8 percent + Tersan 1/2 percent, in Dow 9B 1/2 percent, or in Ceresan M 1/4 percent. The last treatment was a 10-second dip. In the other treatments the corms were soaked for five minutes. These treatments doubled the yield of flowers and corms as compared with untreated."

Comeadow (15) stated in 1948 that in Australia Botrytis blight and rot (as well as dry rot and hard rot) had been effectively controlled by a 48-hour immersion of the corms before planting in a solution of Keotized mercury E (an animal oil emulsion of phenyl mercuric acetate, 1 ounce in 1 1/2 gallons of water). However, he suggested that freshly dug corms should be dipped for only 15 minutes.

Bald (11) found that New Improved Ceresan (2 lb/100 gal) gave better control of the neck rot phase of Botrytis than Lysol or ferbam. In one trial it also gave significant reduction in Botrytis lesions on the daughter corms. He (12) recommends a 30-second dip for trial in place of the standard 15-minute soak in view of results by Young, who showed that less mercury injury may occur. Well-cured corms are probably less injured by chemicals than others.

The writer has also run some disinfection tests before and after cleaning and just before planting. Although there was a slight reduction in the loss from Botrytis rot, it appeared that curing alone was sufficient and most practical under western Washington conditions. Corms are dipped in thiram before planting, but for the control of dry rot.

CORMEL TREATMENT: Most trials with fungicides have been made on corms. Those made on cormels by the writer and by others have usually given disappointing results, regardless of the disease concerned. However, Bald recently (12) briefly described a method developed by Roistacher and Bald whereby all diseases and pests except bacterial scab and virus diseases had been eliminated from bulblets. This method consisted of the following steps: elimination of mummified bulblets; presoaking others overnight in water at room temperature; 30-minute soak in water at 135° F; removal and cooling by plunging into cold water; drying and storing as usual. This treatment must be applied when the cormels are fully dormant. Roistacher has perfected a test with tetrazolium chloride for this purpose. Twenty cormels are split and placed in a 1% solution of tetrazolium chloride in the dark at 70° for four hours. If they are fully dormant they are not stained at all or only stained a light pink. As they become less dormant the intensity of the red color increases, although the rate varies with the variety. (They also stain red immediately after being dug, but this is an indication of physiological activity and not of capacity for germination.)

PLANTING LOCATION: Soil type -- As Hawker (38) has pointed out, the loss is often greatest in the heavier soils and/or soils that are apt to be quite wet, especially late in the season. Peiris (59) obtained percentage losses of 24% to 47% in corms grown in dry soil vs. wet soil under otherwise similar conditions.

Rotation -- The longevity of the organism in the soil, in gladiolus debris, and as independent sclerotia is unknown. Three years might be sufficiently long to permit the fungus to die out. Ordinarily the persistence of dry rot and Fusarium rot would prevent a quicker return to the same location.

Soil treatment -- Hawker (38) tried formalin, mercuric chloride, Uspulun, Aretan, Brassisan, and pentachloronitrobenzene as soil treatments without benefit.

Magie (50) suggested the following practices to prevent the formation of sclerotia: "Burn or bury a foot deep all infected material including bulbs, spikes, florets and leaves. On larger plantings where removal of diseased tops may not be feasible, broadcast 500 pounds calcium cyanamid per acre, then cut leaves immediately after bulb harvest and plow trash under completely."

PLANTING DATE: In order to take advantage of the reduction in rot by digging somewhat early, it is necessary to plant accordingly. Also, the most susceptible varieties should be planted first, followed by those with more resistance.

ROGUING: Hawker (38) obtained less rot in storage in lots that had been carefully rogued in the field, than in those less carefully rogued.

The prompt removal of spikes from the field is particularly important, since flowers are more susceptible than any other part of the plant to Botrytis attack and act as "breeding grounds" for the formation of huge numbers of spores. Spikes should be cut as tight as practicable. Unused ones should be dumped in a distant location, or preferably, in a pit and covered with dirt, lime, or some fungicide to discourage sporulation.

DIGGING: The data and observations previously reported demonstrated that stocks dug early usually develop less rot than those dug late. Naturally it is not feasible to dig all corms early, but that should be the goal as far as possible, particularly with the most susceptible varieties.

On the other hand, observations also indicate that it is often better to delay digging rather than to dig during rain. This, too, is not always possible but digging should be attempted in the driest weather possible.

Although the limited data available do not support the policy of washing corms before curing, the writer believes that washing has merit if a considerable amount of mud adheres to the corms at digging time, as most often happens in silt type soils. Some growers' results support this belief.

Peiris (59) decided that there was no advantage to breaking off the tops of corms immediately after lifting as recommended by Timmermans, except in special cases.

SPRAYING; Wade (72) controlled leaf spots by spraying at weekly or biweekly intervals with Bordeaux, but there was no reduction in corm infection. Bordeaux (plus a wetting agent) has since been recommended (2) in Australia.

Magie (49) was apparently the first to demonstrate the effectiveness of various carbamates in controlling Botrytis blight and flower spot of gladiolus, and such sprays have been successfully used since 1947 by Florida growers. He suggests using 2 quarts nabam (Dithane D-14, Parzate Liquid, etc.) plus 3/4 lb. zinc sulfate (monohydrate powder, 36% zinc) plus 3 to 5 ounces Triton B 1956 per 100 gallons of water; or zineb (Parzate, Dithane Z-78, etc.) which is the prepared zinc salt of nabam. It is a wettable powder and does not require mixing with zinc sulfate. Two pounds are used in 100 gallons, plus 2 ounces of Triton B 1956. The nabam spray will leave less residue than the zineb. Either material will burn the edges of open petals. Magie (50) recommends that spraying begin three weeks earlier than the earliest recorded outbreaks of Botrytis in the area. He suggests one spray per week during dry weather and two or three sprays per week when the disease appears in the vicinity, in order to protect foliage. However, spikes should be sprayed every day in wet weather, otherwise every second or third day since they are constantly growing and exposing new tissue. These fungicides will also control Curvularia and Stemphylium.

Holloman and Young (39) obtained definitely better control with weekly sprays of ferbam (2 pounds per 100 gallons) than with Phygon XL, Puratized Agricultural Spray, or Crag Fungicide 341C, and slightly better than with nabam in Oregon. They recommend ferbam where sale of cut flowers is not involved and nabam if it is a factor.

Manzate has also been reported promising for Botrytis control on gladiolus (12).

TREATING CUT SPIKES: Magie (49) has stated that Botrytis can be effectively controlled on cut flowers without injury by dipping cut spikes for two seconds in a solution of 1 pint of Puratized Agricultural Spray per 100 gallons of water with enough wetting agent added to make a film on the petals. Such a dip will, of course, only destroy spores on the surface and cannot eradicate infections already present.

Recently (December 9, 1952) he informed the writer that a 2- 5-second dip in the regular spray mixture of nabam plus zinc sulfate was also effective in disinfecting cut spikes and did not injure the petals if flowers were cut in the tight bud stage. Vancide 51 was effective when used in the same manner at spray strength.

Bald (12) reported that dusting spikes with Mathieson 275 (pentachloronitrobenzene) checked the infection.

Fischer and Keller (34) found that Botrytis infection of gladiolus flowers in a closed container could be controlled by placing brominated activated charcoal around the spikes. They assumed that bromine was released slowly and acted as a fumigant.

SUMMARY

Botrytis now rates as the number two gladiolus disease in the United States. Its development is dependent upon cool temperatures and high humidity, conditions which are most often encountered on the Pacific Coast and in Florida. It is usually caused by B. gladiolorum, but occasionally by B. cinerea, B. elliptica, and perhaps B. gladioli. All parts of the plant may be infected, resulting in flower blight, leaf spot, neck rot, and corm rot.

Basic control measures are now known, although refinements on some are needed. The main controls are:

1. Planting in a location with good soil and air drainage.
2. Roguing of diseased plants and removal of old flower spikes.
3. Spraying periodically with nabam, ferbam, or zineb sprays during weather favorable for the fungus.
4. Digging as early and in as dry weather as possible.
5. Heat-curing promptly at 85° to 95° F with a relative humidity of about 80 percent for seven to ten days, cleaning and returning to the curing chamber for four to seven days more.
6. Storing at 40° to 50° with a relative humidity of about 70 to 80 percent.

More information is needed on the optimum temperatures and relative humidity for both curing and storing, particularly in relation to condition of the corm. Experiments under way by Dr. Neil Stuart (U.S. Department of Agriculture, Plant Industry Station, Beltsville, Maryland) should yield information on these points (See Addenda, 1).

ADDENDA

1. A manuscript summarizing the results to date has just been received from Dr. Stuart, et al. It is being released for publication to the New England Gladiolus Society and North American Gladiolus Council under the title, "Preliminary report on effects of curing, storage temperature, and relative humidity on flowering and corm production of gladiolus."

Stuart, et al., point out (a) the need to distinguish between heat-drying and heat-curing; (b) the need to distinguish the physiological effects of drying, curing and storage of gladiolus corms on their growth and production as opposed to their effects on disease organisms attacking the corm; and (c) the many factors that influence growth and response of gladiolus corms. (For instance, in one of their experiments "...small corms harvested from cold soil in November dried out rapidly and ultimately died when the relative humidity was maintained at 50 percent and the temperature at 40°. Larger corms harvested earlier and cured in a warm room were not damaged by the same storage conditions.")

They state that "There is some evidence in our tests that low-temperature storage favored multiple-sprout production while slightly higher storage temperature resulted in production of fewer spikes of higher quality and fewer new corms." (40° vs 50° F). They then raise the question as to whether this is caused only by higher temperatures favoring growth of Fusarium or if there is also a direct effect on growth of the plant.

Corms that were stored at 40° F with a relative humidity of 50 percent contained only 13.5 percent moisture at planting time and failed to grow when planted. Others had 21.3 percent moisture at 35° and 70 percent humidity; 52.9 percent at 40° and 85 percent; and 51.3 percent at 50° and 90 percent. Heat-treatment (10 days at 90°) just before planting accelerated blooming.

Until additional information is obtained, they advise gladiolus growers: "... to avoid temperature extremes during curing and storage and to prevent excessive drying of the corms while they are in storage."

2. In connection with experiments on the Fusarium disease, Barton H. Marshall, Jr. recently reported (Relation of wound periderm in gladiolus corms to penetration by Fusarium oxysporum f. gladioli. Phytopath. 43: 425-431, 1953), "...that rapid drying at high temperature aids in preventing infection by Fusarium, and that the high humidity during the curing period is not only non-essential but may be quite undesirable." These results refer mostly to 95° F and 95 percent relative humidity, although other temperatures were tested. Under his conditions, the Fusarium-infected portion of the corm was not completely walled off, even at 95°.

Literature Cited

1. Anonymous. 1948. De Botrytis-aantasting van Gladiolusknollen. Verslagen En Mededelingen Van De Plantenziektenkundige Dienst Te Wageningen, No. 97, October.
2. ________. 1949. Notes by the Biological Branch. Corm rot diseases of the gladiolus. Jour. Dept. Agr. Victoria 47: 125-129. (R.A.M. 28: 455. 1949)
3. ________. 1951. Gladiolus. DeHobaho. (N. V. Holland's Bloembollenhis, Lisse, Netherlands.) March 30.
4. Artschwager, Ernst, and Ruth Colvin Starrett. 1931. Suberization and wound periderm formation in sweetpotato and gladiolus as affected by temperature and relative humidity. Jour. Agr. Res. 43: 353-364.
5. Baker, K. F. 1948. Developments in California floriculture. Flor. Exch. 110, (8) 14, 52. (R.A.M. 27: 566-567. 1948).
6. Baker, Kenneth F., and R. H. Sciaroni. 1952. Diseases of major floricultural crops in California. Booklet published by Calif. State Florists Assoc. April.
7. Bald, J. G. 1951. Diseases of gladiolus in Southern California. North Amer. Glad. Counc. Bul. 26: 107-110.
8. ________. 1952. Stomatal droplets and the penetration of leaves by plant pathogens. Amer. Jour. Bot. 39: 97-99.
9. ________. 1953. Control of disease by heat-curing and dipping gladiolus corms. I. Wound periderm and the extension of lesions. Phytopath. 43: 141-145.
10. ________. 1953. Control of disease by heat-curing and dipping gladiolus corms. II. Incidence of lesions. Phytopath. 43: 146-150.

11. Bald, J. G. 1953. Control of disease by heat-curing and dipping gladiolus corms. III. Dipping Trials. Phytopath. 43: 151-155.
12. ________. 1953. Gladiolus diseases. A progress report on current research compiled from discussions at the Eighth Annual Convention, North American Gladiolus Council. Cleveland, Ohio. January 15-18, 1953. 11 pp. Mimeogr.
13. ________. 1953. Neck rot phase of the Botrytis disease of gladiolus. Phytopath. 43: 167-171.
14. Chase, Stephen. 1950. Curing and storage of gladiolus bulbs. The Gladiolus. New England Gladiolus Society, Inc., Boston, Mass. pp. 62-65.
15. Comeadow, W. A. 1948. New fungicides for gladiolus. Gladiolus Magazine 12: 9-11, 40. (R.A.M. 28: 455-456. 1949).
16. Cropsey, Myron G. 1951. Experiments in drying and storage of gladiolus corms at Oregon State College. North American Commercial Gladiolus Growers Newsletter, No. 7, pp. 2-3, July 2.
17. ________________. 1951. Experiments in drying and storage of gladiolus corms at Oregon State College. North Amer. Commercial Gladiolus Growers Newsletter, No. 8, pp. 4-5, October 1.
18. ________________. 1947. Storage of gladiolus corms. Oregon State Dept. of Agric. Newsletter to Nurserymen No. 48, June 16.
19. Crossley, J. H., and S. Arrowsmith, Jr. 1948. Gladiolus culture in British Columbia. Dominion Exp. Sta. Bul., Saanichton, B. C.
20. Davidson, O. W. 1950. More reports of gladiolus research. North Amer. Glad. Counc. Bul. 21: 17-21.
21. Dennis, R. W. G., and Elsie M. Wakefield. 1946. New or interesting British fungi. Trans. Brit. Mycol. Soc. 29: 141-166. (R.A.M. 26: 172-173. 1947).
22. Denny, F. E., and Lawrence P. Miller. 1935. Storage temperatures and chemical treatments for shortening the rest period of small corms and cormels of gladiolus. Contrib. Boyce Thompson Inst. 7: 257-265. 1935.
23. __________. 1936. Storage temperatures for shortening the rest period of gladiolus corms. Contrib. Boyce Thompson Inst. 8: 137-140.
24. __________. 1938. Prolonging, then breaking, the rest period of gladiolus corms. Contrib. Boyce Thompson Inst. 9: 403-408.
25. __________. 1939. Respiration of gladiolus corms during prolonged dormancy. Contrib. Boyce Thompson Inst. 10: 453-460.
26. __________. 1940. Sensitivity of gladiolus corms during an artificially prolonged rest period. Science 92: 415-416.
27. __________. 1942. Effect of a few hours of chilling upon the germination of gladiolus corms subjected to an artificially prolonged rest period. Contrib. Boyce Thompson Inst. 12: 375-386.
28. Dimock, A. W. 1940. Epiphytotic of Botrytis blight on gladiolus in Florida. Plant Dis. Reptr. 24: 159-161.
29. Dodge, B. O., and Thomas Laskaris. 1941. Botrytis core-rot of gladiolus. Jour. New York Bot. Gard. 42: 92-95.
30. Donk, B., and J. Roggeveen. 1949. Ziekten en beschadigingen der bol- en knolgewassen. N. V. Uitgevers-Maatschappij.
31. Drayton, F. L. 1946. Botrytis or core rot of gladiolus corms--a storage disease. North Amer. Glad. Counc. Bul. 7: 14-16.
32. Emsweller, S. L. 1930. Some results of storing gladioli at various temperatures. Proc. Amer. Soc. Hort. Sci. 27: 550-553.
33. Fairburn, David C. 1934. Growth responses of the gladiolus as influenced by storage temperatures. Iowa Agr. Exp. Sta. Res. Bul. 170.
34. Fischer, C. W., Jr., and J. R. Keller. 1951. Stop the rot in flower shipments. New York State Flower Growers Bul. 65.
35. Forsberg, J. L. 1952. Drying gladiolus corms. Florists' Review 111: 33-34, 45.
36. Gould, Charles J. 1950. Till decay do us part. Gladiolus Magazine, 14: 2+.
37. Grove, L. C. 1947. Growing the gladiolus. Iowa Agric. Exp. Sta. Bul. P 85.

38. Hawker, Lilian E. 1946. Diseases of the gladiolus. III. Botrytis rot of corms and its control. Annals Appl. Biol. 33: 200-208.

39. Holloman, Arthur, Jr., and Roy A. Young. 1951. Evaluation of fungicides for control of the leaf spot disease of gladiolus caused by Botrytis gladiolorum Timmermans. Plant Dis. Reptr. 35: 456-458.

40. Hubert, F. P., and W. H. Wheeler. 1950. Disease survey of domestic bulbs 1948-49. Plant Dis. Reptr. 34: 53.

41. Klebahn, H. 1930. Zur Kenntnis einiger Botrytis-Formen vom Typus der Botrytis cinerea. (Contribution to the knowledge of some forms of the type Botrytis cinerea.) Zeitschr. f. Bot. 23 (Festschr.), pp. 251-272. (R.A.M. 10: 274. 1931.

42. Krone, Paul R. 1947. Infrared heat bulbs for drying gladiolus corms. Michigan Agr. Exp. Sta. Quart. Bul. 29: 281-282.

43. Lauritzen, J. I., and R. C. Wright. 1934. Factors affecting gladiolus in storage. Jour. Agr. Res. 48: 265-282.

44. Loomis, W. E. 1933. Forcing gladiolus. Proc. Amer. Soc. Hort. Sci. 30: 585-588.

45. MacLean, Neil Allan. 1948. New hosts for Botrytis elliptica. Phytopath. 38: 752-753.

46. ________________. 1949. Botrytis diseases of ornamental plants. Unpublished thesis. State College of Washington, Pullman, Washington.

47. Magie, Robert O. 1948. Etiology and control of certain epiphytotic diseases of gladiolus. p. 130. Florida Agr. Exp. Sta. Ann. Rept. for Fiscal Year Ending June 30, 1938.

48. ______________. [date ?] Susceptibility of some gladiolus varieties to the important diseases found in Florida. 9 pp. Mimeographed and unnumbered.

49. ______________. 1950. Spray program for disease and insect control. Gladiolus Magazine, 14: 2+.

50. ______________. 1951. Botrytis and Curvularia disease of gladiolus. North Amer. Glad. Counc. Bul. 27: 85-90.

51. ______________. 1952. Breeding disease resistant gladiolus. North Amer. Glad. Counc. Bul. 30: 78-83.

52. ______________. 1952. Curing and storage of gladiolus bulbs. North Amer. Commercial Glad. Growers Newsletter, No. 13, October 22.

53. Marshall, B. H. 1952. Relation of wound periderm in gladiolus corms to penetration by Fusarium oxysporum f. gladioli. Phytopath. 42: 342.

54. McClellan, W. D., K. F. Baker, and C. J. Gould. 1949. Occurrence of the Botrytis disease of gladiolus in the United States in relation to temperature and humidity. Phytopath. 39: 260-271.

55. McCulloch, Lucia and C. A. Weigel. 1941. Gladiolus diseases and insects. U. S. Dept. Agr. Farm. Bul. 1860.

56. McWhorter, Frank P. 1939. Botrytis on gladiolus leaves in Oregon. Plant Dis. Reptr. 23: 347.

57. Moore, W. C. 1949. Diseases of bulbs. Gr. Brit. Min. Agric. and Fish. Bul. 117: 113-116.

58. Nelson, Ray. 1948. Diseases of gladiolus. Michigan State College Agr. Exp. Sta. Special Bul. 350.

59. Peiris, J. W. L. 1949. The Botrytis disease of gladiolus with special reference to the causal organism. Trans. Brit. Mycol. Soc. 32: 291-304.

60. Pommert, Ralph J. 1952. Editorial Comments. North American Commercial Glad. Growers Newsletter No. 13, October 22.

61. Post, Kenneth. 1949. Florist crop production and marketing. Orange Judd Publishing Company, Inc., New York.

62. Pridham, Alfred Melville Stewart. 1933. The general physiology of the gladiolus. Unpublished thesis. Library, Cornell University, Ithaca, New York.

63. ______________________________, and J. C. Ratsek. 1932. Growth of gladiolus as affected by storage conditions. Proc. Amer. Soc. Hort. Sci. 29: 526-529.

64. Rose, Dean M., R. C. Wright, and T. M. Whiteman. 1942. The commercial storage of fruits, vegetables and florists stocks. U. S. Dept.

Agr. Circular 278: 46.

65. Ryan, R. W., and Paul Ulman. 1953. Joint Research Committee -- NAGC-NACGG -- 1952 Report. North Amer. Glad. Counc. Bul. 33: 23-30.

66. Schmidt, Trude. 1949. The Botrytis rot of gladiolus corms, a new disease for Austria. Pflsch. Ber. Wien, 3, 7-8, pp. 97-111, (Engl. summary). (R.A.M. 28: 575. 1949.)

67. Simmons, S. A. 1949. Research on Botrytis corm rot. North Amer. Glad. Counc. Bul. 17: 93-94.

68. Stofmeel, W. S. 1941. De Botrytis-aantasting van gladiolusknollen en haar bestrijding. (The Botrytis infection of gladiolus corms and its control) Tijdschr. Plantenziekt., 47 (4): 154-163. 3 pl., (R.A.M. 26: 57-58. 1947.)

69. Thornton, Norwood C., and F. E. Denny. 1941. Oxygen intake and carbon dioxide output of gladiolus corms after storage under conditions which prolong the rest period. Contrib. Boyce Thompson Inst. 11: 421-430.

70. Timmermans, Adrienne S. 1941. Het Botrytis-rot der Gladiolen veroorzaakt door Botrytis gladiolorum nov. spec. (Botrytis rot of gladiolus caused by Botrytis gladiolorum, nov. spec.) Publication No. 67, Laboratorium voor Bloembollenonderzoek, Lisse, Holland. December.

71. Van de Pol, P. H., and L. P. Flipse. 1949. Overzicht van de belangrijkste ziekten en plagen in de twuinbouw in 1948. (Survey of the most important diseases and pests in horticulture in 1948.) Maandbl. Landbouw Voor-licht. 6, 3-4, pp. 107-117, 7 figs. (R.A.M. 29: 140. 1950).

72. Wade, G. C. 1945. Botrytis corm rot of the gladiolus -- its cause and control. Proc. Roy Soc. Victoria 57 (New Series), Pts. I-II, pp. 81-123.

73. Weinard, F. F., and S. W. Decker. 1930. Experiments in forcing gladioli. Illinois Agr. Exp. Sta. Bul. 357.

74. Weiss, Freeman. 1940. Botrytis dry rot of gladiolus corms in New York. Plant Dis. Reptr. 24: 119.

75. ______________, and Muriel J. O'Brien. 1952. Index of plant diseases in the United States, Part IV. p. 542. Issued by the Plant Disease Survey.

76. White, N. H. ?1946. Plant disease survey of Tasmania for the three year period, 1943, 1944, 1945. 30 pp. Tasmanian Dept. of Agric. (?1946 Mimeo) (R.A.M. 25: 329. 1946.)

77. Whiteman, T. M. 1936. A preliminary report on the respiration of Souvenir gladiolus corms before and after curing at various temperatures. Proc. Amer. Soc. Hort. Sci. 34: 612-617.

78. Wright, R. C. 1942. The Freezing temperatures of some fruits, vegetables and florists' stocks. U. S. Dept. Agr. Circular No. 447, p. 11. 1937. (Revised Jan. 1942).

79. Yerkes, Guy E. 1948. Gladiolus culture. U. S. Dept. Agr. mimeorgraphed but unnumbered. March.

80.

Additional Literature
(Popularized versions of technical articles)

McClellan, W. D., K. F. Baker, and C. J. Gould. 1948. Survey and appraisal of Botrytis disease on gladiolus crops. Florists' Review. May 13,

Timmermans, Adriana S. 1942. Botrytis gladiolorum nov. spec., de veroorzaker van het Botrytis rot der gladiolen. Publication No. 71, Laboratorium voor Bloembollenonderzoek, Lisse, Holland, December.

Wade, G. C. 1945. The control of Botrytis corm rot of the gladiolus. Jour. Dept. Agr. Vict. 43: 127-130.

WESTERN WASHINGTON EXPERIMENT STATION, PUYALLUP

THE PLANT DISEASE REPORTER

Issued By

THE PLANT DISEASE SURVEY

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

HEVEA DISEASES OF THE WESTERN HEMISPHERE

Supplement 225 May 15, 1954

The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Section of Mycology and Disease Survey serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

PLANT DISEASE REPORTER SUPPLEMENT

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THE PLANT DISEASE SURVEY
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CONTENTS

HEVEA DISEASES OF THE WESTERN HEMISPHERE

M. H. Langford, J. B. Carpenter, W. E. Manis,
A. M. Gorenz, and E. P. Imle

The Hevea rubbertree (Hevea brasiliensis) is native to the jungles of South America. For many years prior to 1910, these jungle trees supplied the bulk of the world's rubber. On these scattered trees growing in their native habitat, disease damage usually was limited and generally passed unnoticed. When large numbers of Hevea trees were brought together in plantations, however, the opportunities for disease spread and build-up increased greatly. Disease control then became a problem of the utmost importance.

The United States Department of Agriculture, in cooperation with commercial companies and the governments of most tropical American countries, since 1940 has carried on a program of research and investigation basic to the development of rubber production in the Western Hemisphere. As new plantings have been established in widely scattered parts of the American Tropics, the major disease problems of the Hemisphere have come to light. It is now known that certain diseases that are serious in some areas cause no appreciable damage in others. All told, there are seven or eight diseases that have proved destructive enough to warrant control measures in one or more areas. The major disease problems of the rubber-growing industry of the Far East are different from those encountered in the American Tropics and are not discussed in this article.

South American Leaf Blight

South American leaf blight is not so well known as chestnut blight but is comparable to it in destructiveness. South American leaf blight of Hevea is endemic in the Amazon Valley and has spread as far south as the State of Bahia in Brazil and as far north as the State of Oaxaca in Mexico. It is now found in Brazil, Colombia, Bolivia, Peru, and the Guianas in South America; in Panama, Costa Rica, Nicaragua, and Guatemala in Central America; in Mexico; and in the island of Trinidad. The history of South American leaf blight and the methods by which it is now controlled are given in a separate article by M. H. Langford and C. H. T. Townsend, Jr.

Phytophthora Pod Rot, Leaf Fall, Dieback, and Panel Decay

Phytophthora pod rot, leaf fall, dieback, and panel decay are symptoms of attack by a single fungus, Phytophthora palmivora. It has a wide host range. Cacao pod rot, of considerable economic importance, is caused by this same fungus. Hevea is attacked, at least sporadically, in most rubber-growing areas of the American Tropics. Serious damage from leaf fall and dieback occurs only under extremely humid conditions. The panel phase of the disease requires attention throughout the rainy season in some areas.

In Hevea plantings in which leaf blight has been controlled by use of resistant clones, Phytophthora often becomes the most troublesome disease. Extreme susceptibility to this disease has precluded further use in some localities of several blight-resistant clones that otherwise were highly suitable as crown clones. During the exceptionally wet weather of 1950-1951, a period of eight months, for example, the disease caused complete defoliation and extensive dieback in some Hevea plantings on the Atlantic Coastal Plain of Costa Rica. At Belterra Estate in Brazil, a limited amount of leaf fall occurs during the rainy season of each year, but the disease becomes inactive during the long dry season. Severe dieback and death of trees has occurred only in certain clones of Hevea benthamiana at Belterra. So far, those are the only localities from which serious outbreaks have been reported.

Leaves of any age may be attacked by Phytophthora. When young leaves are attacked, they may become blackened and shriveled, presenting an appearance similar to that caused by fire damage. On mature leaves, the lesions are inconspicuous but a single one may cause the leaf to drop.

Dieback is usually limited to young shoots and twigs but in some cases major branches, or even the entire crown, may be killed.

The panel phase of the disease is commonly known as black stripe or patch canker. This phase is initiated by an attack of the fungus on the tapping cut or other injuries. The decayed area may cover only a few square inches or it may involve the greater portion of the trunk. Severe cases of black stripe or patch canker may require suspension of tapping for prolonged

periods.

Phytophthora damage in some areas is very limited and the disease requires no special control measures. Resistant or tolerant clones should be used in other areas to guard against excessive leaf fall and dieback.

Studies of resistance to *Phytophthora* are still in an early stage. A small percentage of the Hevea clones growing at the Rubber Plant Substation, of the Department of Agriculture, Los Diamantes, Guapiles, Costa Rica showed remarkably little damage from leaf fall and dieback through months of extremely wet weather in 1950-1951. The progenies of crosses between *Hevea brasiliensis* and certain *H. benthamiana* clones were especially promising and are being tested further.

Control of panel decay caused by *Phytophthora* is now under investigation in Brazil and Cost Rica. Incidence of this phase of the disease can be reduced by opening new panels only during the driest months of the year.

Target Leaf Spot

Target leaf spot, caused by *Pellicularia filamentosa*, is at present an important disease only in Peru and Brazil. It could also become troublesome in the Amazonian lowlands of Bolivia and Colombia, should Hevea plantations be established there. This fungus disease is confined to the leaves and causes damage by defoliation during the rainy season. Repeated defoliations retard the growth and reduce the vigor of young plants. Prolonged dry weather promptly and effectively controls the disease.

Target spot is worst as a nursery disease. It limits, or prevents, the successful budgrafting of seedling stocks and reduces the amount of usable budwood in clone-multiplication gardens. When seedlings develop to the first flush stage in seed beds prior to transplanting, the disease can cause severe damage and may assume the appearance of a web blight. Target spot may also retard the growth of field-planted trees until they have developed a crown of foliage and have undergone several annual leaf changes.

Target spot lesions range up to 2 inches in diameter and usually are zonate. They are covered on the under side by a network of silvery fungus threads. The disease is spread by enormous numbers of wind-borne spores. To a large extent, these are produced at night when conditions for infection are most favorable.

Target spot is most satisfactorily controlled with Dithane (Z-78). Lacking this material, it may be controlled with any of several fungicidal sprays, including the fixed or insoluble coppers or organic fungicides such as Spergon and Fermate. Target spot ordinarily is controlled by the spray program required for leaf blight. Otherwise, applications at 4- to 7-day intervals may be needed to reduce leaf infection and give satisfactory control of leaf fall.

Control through disease resistance has not yet been obtained. Some of the blight-resistant, top-budding clones, however, are quite tolerant to target spot and make fair growth even under severe disease conditions. Selections from a number of species of Hevea other than *H. brasiliensis* have shown varying degrees of resistance to the disease. Through hybridization, therefore, target-spot resistance may eventually be incorporated into commercial clones.

Diplodia Infection of Buddings

Infection of Hevea buddings by the fungus *Diplodia theobromae* is often the major cause of budding failure. This fungus has been troublesome in each of the countries in South and Central America, and in Mexico, where rubber culture has been undertaken. At times, it reduces the percentage of budding success to disastrously low levels. If the budding is done during periods unfavorable for the growth of the rubbertree, the infection may also kill the cambium beneath the budpatch and even spread into the surrounding bark.

Budding is required in the commercial propagation of Hevea to insure high yields. It is also practiced in this Hemisphere to graft blight-resistant tops on high-yielding panel clones. Satisfactory budding success is essential to the economic establishment of Hevea plantings.

Control of budpatch infection has been obtained with a fungicidal treatment using Fermate, which is toxic to *Diplodia* and nontoxic to the cambium of Hevea. The Fermate is mixed with water at a concentration of 200 grams per liter (6.7 ounces per quart). Before cutting the budpatches, the stick of budwood is wiped with a cloth moistened with the fungicidal preparation and allowed to dry, leaving a film of fungicide on the bark. The budding panels on the stock plants are cut in the usual manner and the exuded latex is allowed to coagulate. Then the fungicidal-moistened cloth is used to wipe off the coagulated latex and at the same time leave a

protective coating of the fungicide in the cuts and around the marked-out panel. From this point on, the usual budding technique is followed; that is, flap opened or pulled off, budpatch inserted, and budding wrapped.

In addition to attacking buddings, Diplodia is commonly encountered as a weak parasite in connection with sunscald of the trunk and with dieback of branches weakened by leaf blight. Infection of budwood by Diplodia can be a serious factor in shortening the life of budwood being shipped from one country to another. This is especially true if the budwood loses vitality owing to a considerable lapse of time before use, exposure to unfavorable temperatures, or loss of moisture. Treatment with 20% Fermate before shipment is recommended to check deterioration.

Root Diseases

Root diseases occur in most rubber-growing centers of the Hemisphere but damage has been much lighter than that reported from many areas of the Far East. White root disease and brown root disease have accounted for most of the losses in field plantings. The Helicobasidium root disease has caused losses in nurseries, in some areas.

White root disease, caused by Fomes lignosus, has caused limited damage to Hevea plantings in widely separated parts of the Hemisphere. It has occurred most commonly in Costa Rica and Mexico.

Fomes lignosus attacks the roots of many kinds of trees. When jungle land is cleared, the fungus may continue to live on the roots that remain in the soil. It may infect the roots of young rubbertrees that come in contact with diseased jungle tree roots.

The fungus spreads along an infected root by means of small threads, or rhizomorphs, which may form a white network over the root - hence the name "white root disease".

Wilting of the foliage and branch dieback usually are the first aboveground symptoms of root disease. Eventually, the tree dies or is blown over by the wind.

A disease that causes symptoms characteristic of brown root disease has occurred in field plantings at Belterra Estate in Brazil for many years. In the absence of fruiting structures for a definite determination, the causative fungus is tentatively referred to Fomes noxius. Brown root disease differs from white root disease in that its rhizomorphs form a blackish, rather than a whitish, crust. Also, they usually bind a covering of soil to the infected roots.

Losses from brown root disease have been small, usually not exceeding a few hundred trees annually out of approximately 2 million at Belterra. Recently a root disease, which appears to be the same as that occurring at Belterra, has killed approximately 1 percent of the six-year-old trees in some blocks in a Hevea planting at Belém, Brazil. The incidence of disease is less in younger areas. This disease is now being investigated at Brazil's Instituto Agronomico do Norte. Initial inoculation trials there have indicated that the disease has a low order of transmissibility.

In most rubber-growing areas of the Western Hemisphere, the incidence of root disease has not been high enough to warrant control measures.

Moldy Rot

Moldy rot, caused by Ceratostomella fimbriata, is one of the most serious tapping-panel diseases of Hevea rubbertrees in the Far East. It has caused serious damage in plantations of old Hevea trees in southern Mexico but has not yet become a problem in other areas of this Hemisphere. W. J. Martin, formerly pathologist of the United States Department of Agriculture, has investigated moldy rot and the means of controlling it.

Moldy rot develops rapidly on tapped bark and other wounds and may penetrate both above and below injured areas under conditions of high humidity. Decay of the soft bark and cambial regions hinders bark renewal. In severe cases, this may prevent tapping of the trees after the original bark has been used.

Control of moldy rot was not attained by fungicidal treatments under the nearly ideal conditions for disease development encountered in old plantations in Mexico. Exclusion of the disease from new plantings and attempts to eradicate it when first observed are recommended procedures.

Pink Disease

Pink disease, caused by Corticium salmonicolor, has been noted in many widely-scattered Hevea plantings in this Hemisphere. The fungus has a very wide host range; therefore, distribution over a wide area is to be expected. It has caused damage in some Hevea plantings on the west coast of Guatemala but has attacked only a fraction of 1 percent of the trees in plantings of most other areas. In no case has it caused damage approaching that reported from rubber estates in the Far East.

Attacks of pink disease are usually confined to trees between the ages of two and ten years. Infections most often occur at, or near, a fork. Both the central stem and the branches emerging at the fork may be attacked. A pink incrustation over the affected area distinguishes pink disease from any other disease of Hevea.

The old method of treating pink disease is by excision and burning of all diseased parts of the tree. A major portion of the crown is usually lost as a result of this treatment. Recent work shows that most attacked stems and branches recover without treatment. Painting over the infected area with a coal tar preparation or other disinfectant may reduce inoculum

Glomerella Dieback

Glomerella dieback, caused by Glomerella cingulata, is one of the most prevalent Hevea diseases of the lower Amazon Valley. It occurs in a number of other areas but has not caused appreciable damage in most of them. The imperfect stage of the fungus, the one that is commonly found, is Colletotrichum gloeosporioides.

The fungus may cause rim blight of leaves as well as dieback. The greatest damage is done to young shoots, which are usually attacked at the nodes. Decay sets in and the shoot may break off while its leaves are still green. This distinguishes the disease from Phytophthora dieback, which usually kills the upper part of the flush first.

Severe attacks of Glomerella dieback are largely confined to trees that are not in a vigorous state of growth. The underlying cause of poor growth may be poor soil, inadequate drainage, an excessively dense stand, or other factors. All indications are that the prevalence of Glomerella dieback in the lower Amazon Valley is largely attributable to poor soil. An application of N-P-K fertilizer gave striking reductions in disease incidence in Hevea plantings at both Belém and Belterra, Brazil.

Black Crust

Black crust, caused by Catacauma huberi, occurs only in South America and is confined largely to the Amazon basin. It is one of the most conspicuous and least destructive of all Hevea diseases.

Only young leaves can be infected by black crust. The fungus develops very slowly in the leaf. Visible lesions seldom, if ever, appear on leaves that are less than a month old. The lesions gradually increase in size and may attain a diameter of 1 inch by the time the leaves are six to eight months old. Black crust seldom causes defoliation.

Black crust can be identified by the shining black incrustations that occur on the under side of infected leaves. The crusts are arranged in circles which often are separated by greenish zones.

An occasional clone appears to be extremely susceptible to black crust and may have a large percentage of its leaf area covered with lesions by the end of the rainy season.

The disease is not serious enough to warrant control measures other than avoidance of especially susceptible clones.

Periconia Blight

Periconia blight of Hevea, caused by Periconia heveae, has been reported from Costa Rica, Bahia and the Amazon region of Brazil, and from Mexico. It is not considered a leaf disease of major importance. However, in 1943, during a prolonged rainy period in Costa Rica, this disease reached epiphytotic proportions in a Hevea spruceana nursery and also produced minor damage in a nearby nursery of H. brasiliensis seedlings and budwood gardens. It has been seen on H. guianensis and H. benthamiana.

Lesions occur on both petioles and leaves. Leaf spots are circular to irregular and often are elongated along veins. Several may coalesce to involve an entire leaflet and may bring

about premature abscission. The spots are brown at first, becoming gray at the center with a brown border. The necrotic areas split irregularly and may fall away in part.

Leaves of all ages may be attacked, although greatest damage occurs to the youngest leaves. The disease frequently has followed South American leaf blight infections in areas where susceptible plants were growing. Periconia blight, which may be very destructive during prolonged periods of rainy weather, is reduced almost to the point of disappearance during the dry season.

Hevea spruceana, the most susceptible species, has only limited usage in the research program for production of hybrid seed and is not an important rubber-producing species of commerce. The fact that several *H. brasiliensis* clones, which are resistant to South American leaf blight, have been damaged by Periconia blight at Turrialba, Costa Rica, and elsewhere has alerted rubber pathologists to the possibilities of new outbreaks, even though all evidence to date indicates that it will not become a problem on the important rubber-producing species of commerce, *H. brasiliensis*.

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CONTROL OF SOUTH AMERICAN LEAF BLIGHT OF HEVEA RUBBERTREES

M. H. Langford and C. H. T. Townsend, Jr.

South American leaf blight has long been recognized as the most destructive pest of the Hevea rubbertree. The causal organism of this disease is a fungus, Dothidella ulei. Under humid conditions, it may multiply rapidly and destroy the young foliage of Hevea trees. Trees of any age may be killed by successive defoliations.

Leaf blight seldom causes severe damage to scattered Hevea trees growing in their jungle habitat. However, when the trees are planted row upon row in nurseries or fields, the opportunities for disease development and spread are greatly increased. Thus, this disease, which had hardly been noticed when most of the world's rubber came from wild trees growing in the Amazon Valley, first presented a serious problem when attempts were made to grow Hevea trees on plantations in South America early in the present century. The disease spread from the scattered jungle trees to the planted areas and destroyed most of them. Thousands of acres were ruined and abandoned.

Following the initial failures, interest in rubber production in tropical America waned and support for a sustained effort to solve the leaf blight problem was long delayed. In the meantime, the world became dependent on Far Eastern sources for 97 percent of its crude rubber. There, in the absence of leaf blight, a thriving rubber-growing industry had been developed.

The first coordinated effort toward reestablishment of an appreciable portion of the rubber-producing industry closer to the great centers of consumption in the Western Hemisphere was initiated in 1940. Under the leadership of E. W. Brandes, the United States Department of Agriculture organized a project involving survey work, demonstration plantings, and study of disease problems. This project soon developed into a cooperative effort, with several commercial companies and the governments of most tropical American countries participating. The leaf blight problem received early attention in the cooperative program and two simultaneous attacks were launched against it. These were (1) selection of resistant clones, and (2) use of fungicidal sprays.

Selection of Resistant Clones

The blight-resistant clones that first entered into commercial use were selected on the Ford Plantations in Brazil. During the decade following the beginning of operations at Fordlandia in 1928, more than a million seedlings were planted. The bulk of the seeds came from the Tapajos River area of the Amazon Valley and produced no trees with high resistance to leaf blight. However, among smaller populations of trees originating from Belém and upriver seeds were dozens of individuals that were not damaged when leaf blight defoliated the adjacent trees. Another group of trees showing resistance to leaf blight came from budwood taken from outstanding jungle trees growing in the Acre Territory and the Rio Negro area of the Amazon Valley. The clones now referred to as the blight-resistant Ford clones (Fig. 1) were selected from these groups of material.

With the inauguration of the cooperative program of rubber investigations in 1940, the search for superior blight-resistant material was greatly expanded. Plant scientists were dispatched to Brazil, Colombia, and Peru. There they worked jointly with local scientists in studying the Hevea populations of remote parts of the Amazon Valley. Budwood and seeds were collected from superior trees and established in nursery centers. Hundreds of blight-resistant selections were obtained from these groups of material.

Even before the initiation of the cooperative rubber program, the Goodyear Rubber Plantations Company had initiated a search for blight-resistant material among clones and seedlings of Far Eastern origin. With the entrance of the United States Department of Agriculture into the cooperative program, more than a million seeds were obtained from the Philippine Islands and Africa and were tested in cooperative nurseries in Brazil, Costa Rica, and Panama. If blight-resistant clones could be obtained from this select population, the time-consuming process of cross breeding to combine high yield and disease resistance would be avoided.

The selection work with Eastern material soon demonstrated the need for a quick test to determine the degree of resistance or susceptibility to leaf blight. It was found that many plants that forged ahead in seedling nurseries (with the susceptible young foliage of their growing points above the level at which it could be subjected to the great mass of water-borne inoculum) later proved to have no appreciable resistance to leaf blight. Field plantings, likewise, were found to provide no reliable indication of blight resistance until the trees reached

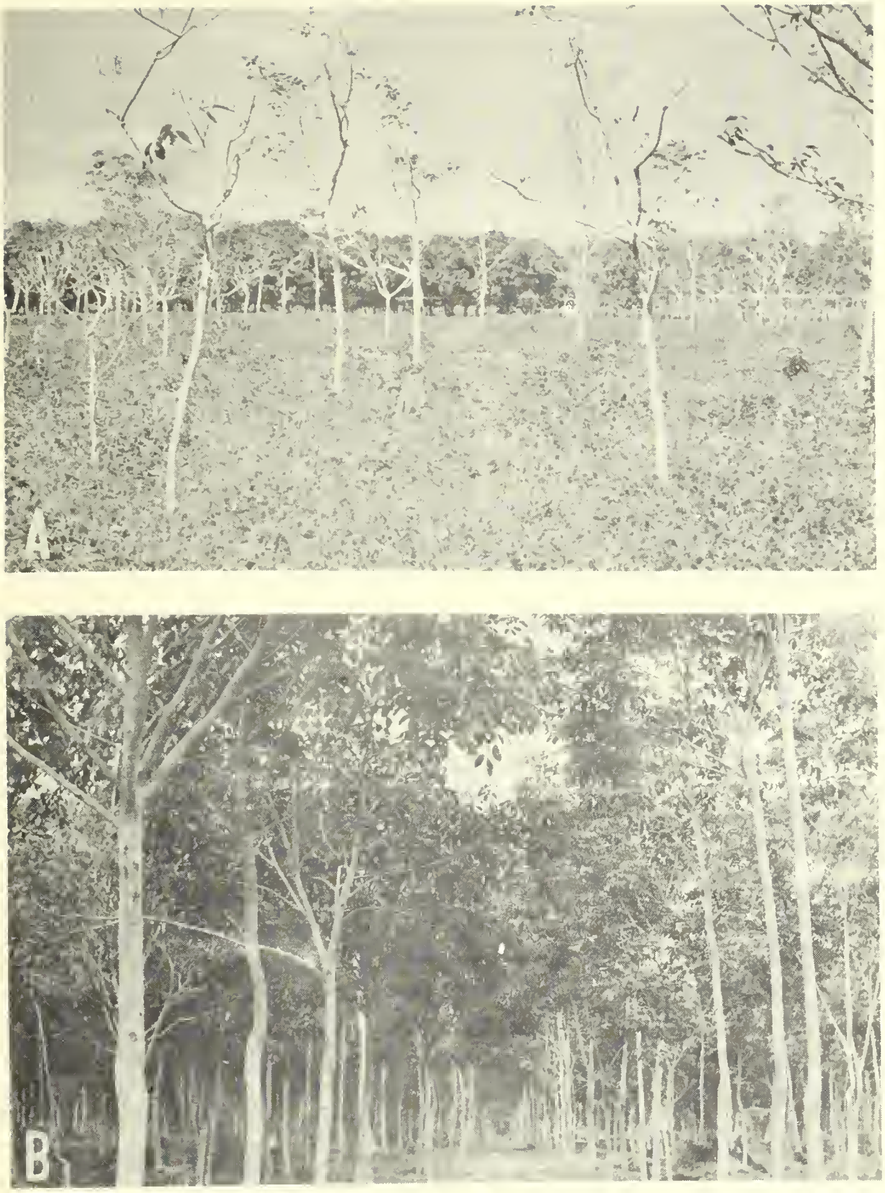

FIGURE 1. Hevea trees growing on a plantation in Brazil: A, Eastern clones; B, Eastern clones top-budded with blight-resistant clones.

the age of four or five years. By that time, the quantity of foliage and inoculum has multiplied many times over, thereby greatly increasing the opportunities for spore dissemination from leaf to leaf and from plant to plant. Thousands of acres of Hevea trees that escaped severe damage for several years were destroyed by leaf blight before reaching maturity. Development of a satisfactory test for resistance was one of the first problems on which pathologists of the United States Department of Agriculture focused attention.

Experiments carried out in Costa Rica in 1942 demonstrated that exposure in special nursery test plots was fully as effective as artificial inoculations, or exposure in moist chambers, in determining the degree of susceptibility or resistance of Hevea clones. A standard testing method whereby experimental clones or seedlings are grown in close proximity to heavily diseased plants through at least one rainy season was adopted. In an area offering favorable conditions for blight development, susceptible seedlings are planted on every third or fourth nursery row and may be protected by applications of fungicidal sprays until they are a few feet tall. Test clones are then planted on the remaining rows and, with spraying discontinued, they are subjected to a constant rain of inoculum. Clones demonstrating high resistance under this test have held up in all field plantings. Many of these were used in plantings that have now been brought into production.

Applying the resistance test described above, it was found that even the most tolerant selections from approximately 1,000 Eastern clones and more than 1,000,000 seedlings of Eastern origin went down under attack by leaf blight. A number of Ford clones and many selections from seedling populations from the Acre, Belém, and Leticia areas of the Amazon Valley demonstrated high resistance but offered little prospect of high yields. Neither the high-yielding Eastern clones nor the blight-resistant Amazon Valley selections alone could provide the planting material for establishment of a competitive, self-sustaining, rubber-growing industry. The two groups of material would have to be used jointly through a bud-grafting procedure until a third group of material, combining high yield with blight resistance, could be created by a breeding program. In the meantime, the blight-susceptible material would need protection in many areas.

Control with Fungicides

Effective control of leaf blight by fungicidal sprays had been demonstrated within a year after the cooperative program of the Division (now Section) of Rubber Plant Investigations was initiated. Among the copper, sulfur, and organic fungicides tested in Panama and Costa Rica during 1940 and 1941, the insoluble coppers proved most practical. Spreaders and stickers increased the efficiency of all spray mixtures. Under rainy-season conditions, the frequency of applications required for good disease control varied from semiweekly to weekly in most localities.

Numerous new fungicides were tested against leaf blight during the decade following adoption of the insoluble coppers as the standard spray material for use against the disease. None proved superior to the insoluble coppers until zinc ethylene bisdithiocarbamate (sold under the trade names Dithane Z-78 and Parzate) was tested on Speedway Estate at Cairo, Costa Rica, in 1950. These tests demonstrated that applications of Dithane or Parzate at 8-day intervals gave more effective control of leaf blight than applications of copper fungicides at 4-day intervals. Tests in other areas have given similar results, and these fungicides are now recommended for general use in spraying Hevea nurseries in blight-infested areas of the Western Hemisphere.

Although it has been demonstrated that leaf blight can be controlled on producing trees by the use of fungicides, economic considerations usually make it necessary to limit spraying operations to nursery plants and very young plantation trees. Therefore, the procedure adopted for establishing high-yielding Hevea plantings in the Western Hemisphere involves temporary spraying followed by top-budding with blight-resistant clones.

Top Budding

Base budding to insure high-yielding trees has long been practiced on rubber plantations but, prior to 1940, top budding was used only on a few experimental trees. Successful fungicidal control of leaf blight in nurseries of blight-susceptible seedlings and on young trees of Eastern clones enabled adoption of top budding as a commercial practice. When required, nursery seedlings are sprayed until they can be base budded with high-yielding clones. These, in turn, are sprayed until they can be top budded at a height of approximately 6 feet with blight-

FIGURE 2. Typical representatives of the groups of material used in, and produced by, the Hevea breeding program; A, a high-yielding, blight-susceptible clone, B, a blight-resistant selection, and C, blight-resistant progeny of A X B.

resistant clones.

In addition to becoming the standard procedure used in establishment of high-yielding Hevea plantations in the Western Hemisphere, top budding saved many thousands of acres of Eastern clones planted in blight-infested areas during the period 1935 to 1940. In plantings where the bark was too old and brittle to permit budding, the trees were pollarded at a height of 6 or 7 feet and, when necessary, a new shoot was protected by spray applications until successfully budded.

It has become increasingly apparent that the growth of panel clones is determined to a large extent by the growth rate of the top clones with which they are budded. Whereas certain vigorous tops bring trees into production within four years under good growing conditions, other tops, which are equally resistant to leaf blight but slow growing, may require twice this amount of time. Thus, the opportunity to reduce the time required to bring trees to tapping size by selecting vigorous topbudding clones is apparent. Certain hybrid clones (progeny of *Hevea brasiliensis* X *H. benthamiana* crosses) are especially promising.

Breeding Program

A breeding program designed to produce plants combining high yield with disease resistance was inaugurated as soon as the cooperative rubber program got under way. The two radically different groups of Hevea clones which were available in the Western Hemisphere provided the required material. One consisted of the best-yielding selections from millions of trees growing in the Far East. These are susceptible to leaf blight. The other consisted of blight-resistant clones selected from large populations of seedling trees growing in South America. These have a low level of yield.

A large portion of the Hevea breeding work has been done at Belterra, Brazil, under the auspices of the Instituto Agronomico do Norte. Since 1944, this program has been directed by G. O. Addison, with assistance from the writers on agronomic and pathological phases of the program. Emphasis has been placed on making known crosses by means of hand pollination. High-yielding Eastern clones and blight-resistant indigenous selections have been used in a large majority of the crosses made to date.

More than 100, 000 cross-pollination progenies have been produced and tested for resistance to leaf blight at Belterra. From these, approximately 8, 000 blight-resistant plants have been selected and budded to the extent of five to ten field trees of each selection. The oldest of these clones are now undergoing yield tests.

A number of families of outstanding resistance and vigor have been produced by crossing certain highly resistant Ford clones with blight-susceptible Eastern clones (Fig. 2). The *Hevea benthamiana* clone F 4542 has given an especially noteworthy performance as a blight-resistant breeding clone. This clone was established at Belterra with budwood from a Rio Negro jungle tree and has proved immune to all populations of the leaf blight fungus to which it has been exposed.

A high percentage of the progenies from crosses between F 4542 and various Eastern clones has proved immune or highly resistant to leaf blight and many selections from these families have demonstrated exceptional vigor. Furthermore, a number of these selections, when back crossed to the high-yielding Eastern parent, have produced families in which more than 50 percent of the seedlings proved resistant to leaf blight.

Within each family produced by crossing a blight-resistant Ford clone with a susceptible Eastern clone, the plants range from highly susceptible to resistant. The percentage of resistant plants, however, varies greatly, depending on the Ford clone used in the cross. When moderately resistant clones are crossed with Eastern clones, the progenies are predominantly susceptible.

Only preliminary yield data have been obtained from clones derived from crosses between Ford and Eastern clones. It is obvious, however, that a large majority of the progenies of such crosses will, like the Ford clones, have a low level of yield. Under Belterra conditions, a very small percentage of the progenies tested has indicated yields which compare favorably with those of the Eastern clones.

From the large population of cross-pollination progenies tested to date, the following conclusions can be drawn:

(1) Certain blight-resistant clones, when crossed with susceptible clones, transmit high resistance to a majority of their progenies.

(2) Certain F_1 selections, when back crossed to the high-yielding susceptible

parent, have given more than 50 percent resistant progenies.

(3) Some blight-resistant selections have proved to be more vigorous than either parent.

(4) A very small percentage of the F_1 selections has indicated promising yields.

Specialization of the Fungus

Wide differences in the growth habit and yield of the Hevea brasiliensis populations of different parts of the Amazon Valley have long been noted and it was anticipated that differences in resistance to leaf blight might also occur. Since 1940, the Hevea populations of several widely separated areas have been studied. Some of these populations have shown a high level of resistance to leaf blight and others have shown extreme susceptibility. The most resistant populations generally occur in the upper part of the Amazon Valley. Those of the Acre Territory of Brazil, the Madre de Dios area of Peru, and the Leticia area of Colombia have been outstanding. The population occurring along the lower Tapajos River of Brazil (the area from which seeds were obtained to initiate the rubber-growing industry of the Far East) has proved extremely susceptible.

After striking differences in the level of resistance of the Hevea trees of different areas had been demonstrated, the pathogenicity of populations of the leaf blight fungus was studied. Wide differences in pathogenicity would make the results of resistance tests conducted in one locality invalid in other localities. Therefore, the fungus populations of rubber-growing centers extending from the State of Vera Cruz in Mexico to the Madre de Dios area of Peru were studied to determine their variability.

Through the cooperation of experiment stations and rubber-growing enterprises, groups of clones originating from the Belém, Tapajos, and Acre areas of the Amazon Valley were established in special test plots at Turrialba, Costa Rica; Port-of-Spain, Trinidad; Belém and Belterra, Brazil; and Tingo Maria, Yurac, and Iquitos, Peru. These clones were grown in alternate nursery beds with heavily diseased seedlings and were classified for resistance during the wettest part of one or more years. In addition to the tests on clonal material, seeds originating from many parts of the native habitat of the Hevea tree have been tested in strategic localities throughout tropical America.

A degree of specialization of the leaf blight fungus to the Hevea population that has long occurred in the same area with it usually exists. Specialization is especially pronounced in areas where a single strain of Hevea predominates. It may become less distinct after other strains of Hevea are introduced and cultivated over a period of years. In some cases, this change may be brought about by the rapid multiplication of hitherto minor components of the fungus population that are virulent on the new introductions. In other cases, however, the evidence indicates that the change occurs through the rise of a new and more virulent strain of the fungus.

In several localities, blight lesions have suddenly appeared on clones that previously had shown high resistance to leaf blight. When used to inoculate young leaf flushes of other plants of the same clone, the spores produced by these lesions have always shown greater virulence than spores taken from seedling plants growing in the area. Closely related clones, that is clones of the same origin or parentage, may also be more heavily attacked by this new strain of the fungus. In no case, however, has it proved more virulent to a wide range of components of the Hevea population.

A strain of the leaf blight fungus which appeared at Belterra, Brazil, in 1946 provides the most striking example yet recorded of the occurrence of a new physiologic race of the leaf blight fungus. On a number of Ford top-budding clones that had shown near immunity to leaf blight since 1939, numerous disease lesions began to develop in 1946. This strain of the fungus soon became established over the entire plantation but defoliation has not been heavy enough to cause serious damage to the affected clones. Insurance against extensive damage by new strains of the fungus is provided by using a mixture of resistant tops in commercial plantings of Hevea.

A second safety factor against the inroads of new strains of the fungus is provided by the diminishing chance of severe disease attack as Hevea plantings approach maturity. After the trees reach the age of seven or eight years, practically all new growth emerges during the annual leaf change period -- the driest and least favorable portion of the year for blight development. When this stage has been reached, the fungus often fails to maintain a supply of viable inoculum, especially on clones having a fair level of resistance. New foliage, therefore, emerges and passes through the young susceptible stage without being attacked.

Long Distance Spread of the Fungus

Spores of the leaf blight fungus may be disseminated by the wind. This method of dissemination doubtless accounts for a great majority of the cases of spread of leaf blight over long distances. The spore loads carried by air currents have been studied by exposing disease-free potted plants at graduated distances from blight-infested plantings. Additional information has been obtained by noting the initial occurrence and rate of spread of leaf blight in new Hevea plantings.

Studies on spore viability have shown that a small percentage of the spores resting on the dry surface of plant foliage, or stored in glass plates at room temperatures, retains the power to germinate and infect for a week or more. This enables viable spores to be carried hundreds, or even thousands, of miles in strong air currents.

Borne by the wind, leaf blight has moved into northern Colombia, Nicaragua, Guatemala, and a large number of hitherto disease-free localities in various countries since 1942. In anticipation of such spread, the program in the Western Hemisphere was planned on the assumption that all rubber-growing areas would eventually become blight infested. The time required for the disease to bridge the Pacific and establish itself in the great rubber-growing areas of the Far East is problematical. The material now available, however, provides the means for successful culture of Hevea rubber regardless of the presence of leaf blight.

Summary

Some of the early losses that attended the development of plantations in tropical America may be attributed to the failure to recognize the hazards of Dothidella ulei, the fungus that causes leaf blight. From experience and information acquired during those early attempts and intensive research, techniques have been developed that have brought South American leaf blight within the realm of control. Because resistance to leaf blight has been realized and effective fungicidal controls, where needed, have been proved, a definite goal in the rubber program has been attained. As far as this disease is concerned, it now is possible to place more emphasis on the genetic, agronomic, and horticultural aspects of rubber culture than on the pathological aspects.

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PHYTOPHTHORA LEAF FALL AND DIEBACK

W. E. Manis

Only recently has Phytophthora leaf fall and dieback on Hevea rubbertrees become a major disease problem in high-rainfall areas of Central America.

The devastating effects of the causal pathogen, *Phytophthora palmivora*, on Hevea have long been recognized in the monsoon regions of Burma and South India and in sections of Ceylon and Malaya. The disease occurs during the rainy season on the Belterra Estate in Brazil, but is arrested during the extended dry period.

Until late 1950, *Phytophthora* on Hevea (other than as a panel disease on the Speedway Estate in Costa Rica) was a minor disease at both the Cooperative Rubber Plant Field Station of the Department of Agriculture at Turrialba, Costa Rica, and at the substation, Los Diamantes.

A serious outbreak in 1950 was of particular interest where cacao pod rot, caused by the same organism, *Phytophthora palmivora*, abounds. Many cacao holdings adjoin Los Diamantes. The same general conditions exist near the Speedway Estate at Cairo.

No attempts at fungicidal control in those cacao plantings have been made. From the inception of the experimental work at Los Diamantes up to 1950, the incidence of Phytophthora damage to the rubbertrees was insignificant. Despite the nearby abundance of inoculum only an occasional nursery plant or a young field plant had been affected.

The causal agent, *Phytophthora palmivora*, unlike *Dothidella ulei*, which is responsible for the South American leaf blight, is not restricted to attacking young leaf and stem tissue. *Phytophthora* may infect mature leaves and petioles, green seed pods, green stem tissue, and bark, as well as immature leaves and branches.

One of the best diagnostic characters for the leaf-fall phase of the disease is a single petiole lesion, which in itself is enough to cause the leaf to drop. Mature leaflets may be attacked at any point, but the fungus most frequently enters at the base or the tip of the leaflets. Immature leaves wilt rapidly and turn dark, as though scalded. Succulent, developing branches are generally attacked about midway between the parent branch and the unfolding new leaves. From that type of infection, the fungus may move downward into the older branches and cause extensive dieback or kill the entire crown.

Development and perpetuation of *Phytophthora* in plantation rubber needs specific climatic conditions. Long periods of continuous rainfall, cloudy weather, and cool nights favor the fungus. Bright days and high temperatures arrest it and, if they last long enough, may check the disease. Therefore, the disease has not attained a ranking in importance equal to that of South American leaf blight, which has been responsible for retarding the spread of Hevea plantings in the Western Hemisphere.

In February of 1951, five months after the initial outbreak at Los Diamantes, Phytophthora leaf fall appeared at the Turrialba station and at the Speedway Estate. We do not assume that the disease was carried from Los Diamantes, some 40 miles from Turrialba and 18 miles from the Speedway Estate. The causal agent was present and needed only the proper impetus -- exact weather conditions -- to set it off.

Los Diamantes, in the Atlantic zone of Costa Rica, is at an elevation of 800 feet. The average annual rainfall is 176 inches. The average monthly rainfall varies from 7.12 inches minimum to 25 inches maximum; the lowest monthly total recorded is 1.64 inches and the highest is 51.58 inches. The longest dry period since 1942 was 22 days. Occasional dry periods of as much as ten days occur, but rainless periods mostly last two to five days. The temperature range is not great. Temperatures rarely are above 90° F or below 60°.

Weather during the last months of 1950 and the first half of 1951 favored the development and activity of the fungus on Hevea. Rainfall for the last three months of 1950 was above average. The prevalence of Phytophthora infection on cacao, manifested as pod rot, also indicates that climatic conditions in Atlantic Costa Rica must be at near the optimum point most of the year for this host-parasite relationship.

Phytophthora leaf fall was first observed at Los Diamantes on clone F 409, resistant to the South American leaf blight. The clone has been highly susceptible to *Phytophthora* at the Belterra Estate, but at Los Diamantes, about 150 trees had shown no predisposition to attack by *Phytophthora palmivora* despite the abundance of inoculum on the neighboring cacao plantings, and it was hoped that *Phytophthora* as a major disease might not affect local plantings.

This hope was shattered for trees at the Turrialba and Los Diamantes stations. After escaping the disease for 8 years, and at the Speedway Estate for 14 years, the trees were at-

tacked by a virulent epidemic, particularly at Los Diamantes, where trees were killed outright, or the crowns were greatly reduced with no opportunity of refoliation for six or seven months. At Turrialba, leaf fall continued for ten months.

Seed pods are regarded as the most susceptible part of the plant and diseased pods are generally considered responsible for the rapid dissemination of the disease in plantations. At the time of the initial outbreak at Los Diamantes most of the trees were not of seed-bearing age. Seeds produced on a few trees were quickly destroyed. This and subsequent outbreaks of epidemic proportions were sustained by the presence of active fungus in the cankered branches of infected plants.

Phytophthora spread rapidly from the eight-year-old trees of clone F 409 through 11 other leaf-blight-resistant clones in the same planting. All the clones are Hevea brasiliensis selections except F 6395, which is a seedling selection of a natural hybrid between H. brasiliensis and H. spruceana. It was the only clone in this planting that retained most of its mature leaves. The others were 95 to 100 percent defoliated, and had from mild to extreme dieback in the branches.

Of the 12 clones, three belong to a group recommended as standard blight-resistant top-working clones -- F 1620, FB 54, and FB 3363. Clone F 1620 was so severely infected that the cankers formed at the branch unions exuded sufficient latex to cause the ground cover directly below to become white. Clones FB 54 and FB 3363, although denuded, did not have as much dieback as did F 1620. The crowns of F 409 were 75 to 80 percent killed back. This clone had been excluded from the standard list of desirable top-working material because of its Phytophthora susceptibility in Brazil.

Besides the three clones designated above as standard top-working clones, two others, F 1619 and FB 3333, are in wide usage and have been budded extensively at Los Diamantes, where their complete susceptibility to Phytophthora has been shown. These five clones have been recommended on the basis of their behaviour in Brazil, where they have shown excellent leaf-blight resistance, good form, buddability, and no apparent damage from Phytophthora. The difference in infection at the different locations indicates that strains of Phytophthora palmivora exist on Hevea. From the severity of the infection at Los Diamantes, the Costa strain is more virulent than the strain at Belterra, Brazil.

The original outbreak at Los Diamantes occurred in an eight-year-old planting. From there the disease spread to the nearby nurseries and to both close and distant field plantings, which range in age from one to seven years.

Only the blight-susceptible, high-yielding Far Eastern clonal nurseries were under spray treatment when Phytophthora appeared. It was soon evident that all nurseries could be maintained only by fungicidal control. Dithane, the fungicide used so effectively against South American leaf blight, was used for Phytophthora control in the nurseries. As long as the plants could be sprayed once or twice weekly, depending on the amount and intensity of rainfall, the results were excellent. During periods of 10 days or more of continuous rain, spraying was impossible and the damage to both seedlings and budded nursery stock was great.

Varying degrees of tolerance to Phytophthora were observed among the different groups of seedlings in the nursery. Most damaged by Phytophthora were Hevea brasiliensis seedlings from the Madre de Dios region of Peru which possessed a high degree of resistance to South American leaf blight. Seedlings from clone F 1620 and other seedlings from mixed H. brasiliensis clones were highly susceptible to Phytophthora. Seedlings from the H. benthamiana clones F 4541 and F 4542 were highly tolerant of it. F 4542 exhibited a higher degree of tolerance than did F 4541. In the plants of F 4542 only the young leaves and new growth were attacked. Typical leaf fall of mature leaves was not observed. Stem lesions that occurred on the H. brasiliensis seedlings were not found on these two groups of benthamiana seedlings.

Clone F 4542, a jungle selection made by the Ford Plantations Company from the Rio Negro region in Brazil, because of its almost complete immunity to leaf blight has been used successfully and extensively as a resistant parent in the breeding program. This clone has shown a high level of resistance to Phytophthora in Brazil. At Los Diamantes, Costa Rica, on five-year-old tops of this clone, severe injury to immature leaf and stem tissue has occurred.. Leaf spotting on hardened leaves has been noted but neither typical leaf fall nor cankers in brown bark have been found.

Adjacent to the first Phytophthora-attacked area is an experimental planting containing eight trees each of 60 different leaf-blight-resistant selections. The experimental clones fall into three general classes: F_1 hybrids between high-yielding leaf-blight-susceptible Hevea brasiliensis clones of Far Eastern origin and blight-resistant H. benthamiana clones; F_1 progeny from blight-resistant and high-yielding H. brasiliensis clones; and blight-resistant H.

brasiliensis tops F 1619, F 1620, FB 54, FB 3363.

The top clones are budded in equal proportion over the entire area. Phytophthora spread through the planting with amazing rapidity. Only a few of the four-year-old trees were producing seeds at that time and, as would be expected, they were the first trees infected. As the disease progressed, defoliation and dieback continued until only a few plots of test trees remained healthy except for limited and restricted infections.

Three clones, IAN 45-586, IAN 45-605, and IAN 45-717, showed tolerance to Phytophthora leaf fall for over eight months. During that time they were bombarded constantly by quantities of inoculum from both sides, the inoculum being present in the twigs and branches of the control trees. Clone IAN 45-586 was bearing a seed crop in October, when Phytophthora appeared in the planting. The disease destroyed the seed pods, but leaf fall did not take place. In March of 1951, at a time when new growth was being put out, the succulent tips of this clone were injured but no dieback was observed below the last matured flush of leaves. On clone IAN 45-717 only a few young shoots were damaged.

One more clone showed some degree of tolerance, but typical Phytophthora leaf fall occurred to a limited extent. This clone, IAN 45-443, did not become denuded, as did the controls and the majority of the experimental clones. It is an F_1 progeny, having as parents H. brasiliensis clones F 409 and Tj 1. F 409 is a highly susceptible clone. Although IAN 45-443 holds its leaves well in older trees, the young plants in nursery areas are so susceptible to stem injury that multiplication of this clone is almost impossible unless it is maintained under spray.

In Brazil and Costa Rica, F 4537, a pure Hevea benthamiana clone, has shown a marked degree of susceptibility to branch dieback and stem cankers due to Phytophthora. Clone F 4542 is highly resistant to both. Progeny of F 4537, IAN 45-586, and IAN 45-605 developed stem and branch cankers during 1951-52, while IAN 45-717, with F 4542 as one of its parents, has remained free of cankers through January 1954.

The high degree of tolerance evidenced at Los Diamantes and also at Turrialba by clone IAN 45-717 under optimum conditions for fungus development cannot be attributed to chance escape. Annual girth measurements in the above-mentioned experiment were taken in March of 1951, 1952, and 1953. A correlation was observed between growth rate and degree of both defoliation and branch injury. The more severe the damage, the more retarded was the growth; the more tolerant the clone, the greater was the growth.

A 40-acre test planting at Los Diamantes has been top-budded with 28 selected leaf-blight-resistant clones to study the compatibility and the performance of these clones as tops on high-yielding Eastern clone panels. The tops are well replicated, budded in monoclone rows of 22 trees per plot. The north half of the area is top-worked with five standard blight-resistant tops, F 1619, F 1620, FB 54, FB 3363, and B 363, and two blight-resistant species tops, F 4542 (Hevea benthamiana), and F 5004 (H. guianensis). The south half of the planting is top-worked with 21 different selected experimental blight-resistant tops and F 1619 used as a control. The 21 experimental clones fall into two groups: 7 F_1 H. brasiliensis clonal crosses, and 14 F_1 hybrids, all with H. benthamiana F 4542 as one parent and a high-yielding H. brasiliensis as the other parent. In 12 of the hybrids, Tj 1 is the high-yielding parent and in the remaining two it is AVROS 363.

The oldest of the tops in this planting are five years old. The nearest other planting is 0.6 of a mile distant. Phytophthora first appeared in the south section of the planting on F 1619 tops in December 1950. The plots of this clone could readily be marked by their lack of leaves. The disease soon moved into the north section of the planting where defoliation and dieback on the standard tops and on F 5004 was severe. H. benthamiana F 4542 showed no typical leaf fall but tip injury did occur.

In the south section, only the control and some of the Hevea brasiliensis clonal crosses were heavily attacked. The contrast between the two sections of this planting was so striking that there can be no doubt of the presence of the resistance factors as contributed by the H. benthamiana clone F 4542. Some of the hybrid clones showed considerable tip injury, but none was defoliated as was the control, F 1619, in all of its 18 replications in the south half of the test during the 1950-51 epidemic. The more promising Phytophthora-tolerant clones, based on preliminary observation, were FX 469, FX 614, FX 645, and FX 649.

During late 1952 and early 1953 there was a shorter period of Phytophthora-favorable weather that was almost identical to that of 1950-51. The disease followed the same pattern of movement and defoliation through the planting. Observations in early 1953 confirm the four preliminary selections noted above, and clone FX 590 has shown up sufficiently well to warrant its inclusion in the promising group chosen from this 40-acre planting.

It was fortunate that we had a large number of blight-resistant IAN, FX, and F Brazilian clones in Costa Rica, where they have been subjected to a long-term, unplanned Phytophthora field test. The clones were distributed to the Costa Rica station through the cooperation of the Instituto Agronomico do Norte, Belém, Pará, Brazil.

Early in December 1950, at both Turrialba and Los Diamantes, young plants of the FX clones and F 4542 used in this compatibility test were inoculated with diseased tissue from freshly infected seed pods. Inoculations were made into the green bark between the second and third whorls of leaves below the growing shoot. All clones, including F 4542, gave a positive reaction to this type of inoculation. That *Phytophthora* developed in wounded tissue of each of the inoculated clones is no real indication that these clones might not have resisted normal infection of unbroken tissue; that is, entry of the fungus into mature leaves, petioles, or unwounded bark tissue. The presence or lack of some mechanical protection over the vulnerable plant parts may be an essential factor determining resistance or susceptibility to leaf fall. The glossy coriaceous type of leaf is found on most plants showing tolerance to *Phytophthora*.

The epiphytotics which occurred in Costa Rica in 1950 and 1951 and again in 1952 and 1953 were of extreme severity. The weather conditions responsible for their severity were of extreme nature. There is every indication that this may be repeated and that it may occur elsewhere. From these Phytophthora epidemics, intensive and extensive, has come a sounder basis for the continued studies on resistance to this disease in Hevea.

It has been shown that the standard top-working clones, F 1619, F 1620, FB 54, FB 3333, and FB 3363, can no longer be used in the Atlantic zone of Costa Rica, nor should they be used where similar climatic conditions prevail.

Tolerance, at a degree approaching resistance, has been found in some of the clones resistant to leaf blight. This valuable material is immediately available for top budding and, since it was brought to the fore under such severe conditions, carries with it the assurance needed for the continuation of successful plantation development in the vast potential rubber-producing areas of the Atlantic coast of Central America. Table 1 presents the Phytophthora-tolerant clones now recommended for Costa Rica by clone source.

Table 1. Hevea plants at Los Diamantes, Costa Rica, that showed a high degree of tolerance to Phytophthora leaf fall.

F_1 hybrids or clonal crosses	Cloned jungle selections	Clonal seedlings
IAN 45-717 (PB 86[a] X F 4542)	F 4542[b]	F 4542
FX 614 (F 4542 X Tj 1[a])	F 6395[c]	F 4541[b]
FX 469 (F 4542 X Tj 1[a])		
FX 645 (F 4542 X Tj 1[a])		
FX 649 (F 4542 X Tj 1[a])		
FX 590 (F 4542 X Tj 1[a])		
IAN 45-443 (Tj 1 X F 409[a])		

[a] *Hevea brasiliensis*.
[b] *H. benthamiana*.
[c] Natural hybrid between *H. spruceana* and *H. brasiliensis*.

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THE PLANT DISEASE REPORTER

Issued By

THE EPIDEMIOLOGY UNIT

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

THE EFFICACY OF FUNGICIDES IN THE CONTROL OF CERTAIN GENERA OF PLANT-PATHOGENIC FUNGI: A LITERATURE REIVEW

Supplement 226

July 15, 1954

The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Plant Disease Epidemics and Identification Section serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

PLANT DISEASE REPORTER SUPPLEMENT

Issued by

THE EPIDEMIOLOGY UNIT
PLANT DISEASE EPIDEMICS AND IDENTIFICATION SECTION

Horticultural Crops Research Branch Plant Industry Station, Beltsville, Maryland

THE EFFICACY OF FUNGICIDES IN THE CONTROL OF CERTAIN GENERA OF PLANT-PATHOGENIC FUNGI: A LITERATURE REVIEW[1]

P. M. Miller and M. B. Linn[2]

Plant Disease Reporter
Supplement 226 July 15, 1954

Is zineb equally effective or ineffective against species of Septoria occurring on celery, chrysanthemum and tomato? If a new disease caused by an undescribed species of Alternaria were to require chemical control measures, would control of the disease be expedited by a knowledge of which fungicide is most effective against Alternaria solani on tomato? The ~~answers~~ answers to these questions require a knowledge of the protective value of fungicides for the pathogens concerned and, perhaps, more fundamental knowledge of fungicide-pathogen specificities. The results of numerous field tests with fungicides have been well summarized (1, 2, 3, 4, 5, 6, 7, 8, 9), but the results are detailed by crops rather than by pathogens making it difficult without detailed study to arrive at any prediction as to fungicide-pathogen relationships. If comparative values or control-indices for most present-day fungicides against major groups of plant pathogens could be developed, such information might be extremely valuable if a new pathogen, regardless of source, should become epiphytotic on plants vital to our economy.

This paper is the result of an attempt to determine by means of a literature review if and to what extent several types of fungicides exhibit differences in the control of 23 plant-pathogenic species in four well-known genera of fungi. Despite the fact that considerable thought has been given to possible means of evaluation, the writers realize that criticism will be directed toward the evaluation-methods finally developed[3] and towards some of the conclusions. No attempt has been made to decide what fungicide should be recommended for controlling any particular species and none of the conclusions should be interpreted in this way. A recommendation as such is determined to a considerable extent by factors such as phytotoxicity, availability, and comparative costs and is primarily the "headache" of the individual pathologist.

The present survey covers the period 1942 to 1952 and includes tests reported from each of the 48 States and from Brazil, British Columbia, Costa Rica, Germany, Hawaii, Ontario, Switzerland and New Zealand. The year 1942 was chosen as the starting point primarily because it marks the beginning of extensive field testing of organic fungicides for the control of fruit and foliage diseases.

The 23 species of pathogenic fungi covered in this survey belong in the genera Alternaria, Cercospora, Colletotrichum, and Septoria. Several of the species in these genera are important pathogens and occur on a wide variety of plants. An attempt was made to include in the survey all species on which chemical control studies have been reported since 1942. However, the survey does not include data from experiments where it was apparent that more than one pathogen was present. The suscepts affected by these fungi are listed in Table 1.

Four fungicides were employed as standards with two or more used in developing the control-indices (Tables 3-8, 10). These standards (fixed copper, bordeaux mixture, ziram, and zineb) were chosen as such because they appear to have been used in a majority of tests against all pathogens included in the survey. For the results to be considered experiments had to include at least two standards with one of these an organic fungicide.

Fungicides were evaluated whenever possible by classes as shown in Table 2. Only those

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1 A revised and condensed version of a thesis submitted by the senior author in partial fulfillment of the requirements for the M. S. degree in the Graduate College of the University of Illinois.

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3 Acknowledgement is made of the valuable assistance rendered by Dr. J. A. Jackobs, Department of Agronomy, University of Illinois, in developing the control-index formula.

fungicides and mixtures shown in this Table were considered in developing control-indices. In several tests fungicides were applied in combination with insecticides. To reduce the variables arising under these circumstances, fungicides combined with insecticides other than DDT, parathion, or lead arsenate were not evaluated.

Investigators have used various means of rating the efficiency of fungicides, thus making comparisons among tests exceedingly difficult. In summaries such as those in the Plant Disease Reporter Supplements, a few have employed the ratings "excellent," "good," "fair," and "poor," or a numerical rating system, while others have named the best fungicide without attempting further classification. A majority of tests has been reported in more specific terms, *e.g.*, percent of infected leaves or fruit or percent defoliation.

Effectiveness of the fungicides in controlling the pathogen concerned was the only criterion employed in this survey. Any differences in efficacy, however small, were sufficient to rate the fungicide being evaluated as superior or inferior to the standards. The results of statistical analyses by individual investigators were not used in the evaluations since they were not provided in all instances. Rankings based on yield, phytotoxicity, and personal preferences were not considered for these may well be related to factors other than fungicidal specificity. Generalized summaries such as have appeared in the Plant Disease Reporter Supplements were employed only whenever it was apparent that these accounts were not superseded by publication of specific data elsewhere.

Although the writers have listed most of the literature consulted, no attempt has been made to give any but a few major citations for specific tests because of space limitations in the tables. Some idea of the complexity and scope of the evaluations can be gained from the fact that nearly 8,000 individual comparisons between compounds were made in computing all of the indices.

METHOD OF EVALUATION

The computation of the control-index for the fungicide to be evaluated is based on a series of comparisons of the disease control provided by the fungicide with the control obtained from the fungicide standards which happened to be in the test concerned. The control-index is computed from the equation, $C\text{-}I = \frac{((1 \times S) + (0.5 \times E)) \times 100}{T}$. In this equation S is the number of comparisons in which the fungicide to be evaluated was superior[4] to the fungicidal standard; E is the number of comparisons in which the fungicide and standard were equally effective; T is the total number of comparisons involved in the computation including those where inferior ratings were obtained; and 100 is an arbitrary constant used to avoid index values less than one. The value E was always multiplied by 0.5 to insure that equally effective control would be taken into account in calculating the index.

The following actual computation of a single control-index will serve to illustrate the way in which the formula is utilized. In 41 comparisons for control of *Alternaria cucumerina*, zineb was superior to fixed coppers 7 times, equally effective 13 times, and inferior 21 times. The control-index for zineb compared with fixed copper would be calculated from the formula as follows: $\frac{((7 \times 1) + (13 \times 0.5)) \times 100}{41} = 32.9$. The control-index and total number of comparisons of zineb with fixed copper appear in Table 3 as "33 (41)". Since the index is less than 50, this signifies that zineb was inferior to fixed copper in 41 comparisons. Contrariwise, an index higher than 50 would have indicated that zineb was superior to fixed copper.

The total control-index for a fungicide compared with all standards is computed according to the same formula but the components are obtained in a slightly different manner. The S values used in the calculation of the index under each standard are added to obtain the S utilized in calculating the total index for the fungicide being evaluated. The E and T values are handled similarly. The control-index for a genus is obtained by a summation of S, E, and T values from the species-indices.

Under this system fungicides with indices between 50 and 100 would be expected to give a moderate to high degree of control provided a total of 10 or more comparisons had been made.

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4 The value 0 and letter I were chosen for each comparison in which the fungicide was inferior to the standard. However, these obviously have no effect in calculating the index and, therefore, can be ignored.

On the other hand, fungicides with indices below 50 would be less effective than the first group.

DISCUSSION

One inherent difficulty in attempting to rank the efficiency of a number of fungicides over a period of years is the probability that changes have been made in composition and formulation of the fungicides. It is apparent that such changes may influence not only fungicidal efficacy *per se* but also retentivity, coverage, and other physical and chemical properties of the fungicide. As Horsfall (32) has pointed out, a chemical may have a high fungicidal value but a low protective value if tenacity is poor. Fungicides containing zineb or dichlone can be cited as examples of those which have been modified since their introduction in order to increase the fungicidal or protective value or to decrease phytotoxicity.

Although a control-index of 50 or above indicates that a fungicide would provide moderate to good control, some consideration must be given to the number of comparisons, tests, and standards involved in the computation. Thus, the Manzate index of 82 based on 103 comparisons (Table 6 -- *C. phomoides*) is likely to have more significance than an index of 81 from 8 comparisons (Table 6 -- *C. lagenarium*). One might assume at first glance that C-O-Z would give a higher degree of control of *S. lycopersici* than the fixed coppers (Table 8). However, the C-O-Z index was derived from only one comparison with zineb, one with ziram (which is relatively ineffective against *Septoria* spp.), and two with fixed copper.

The validity of the method followed in computing the indices can be demonstrated by a comparison of the indices obtained against *Alternaria solani* on potatoes and on tomatoes (Table 4). Where fungicides had been used on both crops, the indices are in general agreement with the possible exception of those for bordeaux mixture.

The results of this survey indicate that Manzate is a very effective fungicide against most species in the four genera. They suggest also that very few of the organic fungicides are as effective as the copper compounds against *Cercospora* spp. and *Septoria* spp. The coppers appear to be relatively poor against *Colletotrichum* spp.

The writers were aware at the outset of this survey that the results, in whatever form expressed, would not always be in agreement with those obtained by individual investigators. One example of discrepancy is in the control of *Septoria lycopersici* with dichlone (Phygon) (Table 8). Nagel and Richardson (40) found that Phygon was definitely superior to Yellow Cuprocide, Dithane D-14 + zinc sulfate + lime, bordeaux mixture, Spergon, and Fermate in controlling this pathogen. Yet when all tests included in the present survey are considered, the index of 45 for dichlone is found to be somewhat below 62 for fixed copper and 54 for zineb. Actually *S. lycopersici* is one of the most difficult leaf-spot pathogens to control with the fungicides presently available. Thus, any commercially available fungicide with an index over 40 would be comparatively effective.

Although Neergaard (41) states that *Alternaria solani*, *A. dauci*, and *A. porri* generally differ only in pathogenicity, the compiled data suggest the possibility that the three species are dissimilar in their susceptibility to fungicides. Few comparisons are available for *A. porri* (Table 3) but the data indicate that zineb has a moderately high control-index against this species. In contrast, zineb would appear to be rather ineffective against *A. dauci* (Table 4). Ziram has a comparatively low index against *A. solani* (Table 4) and a high index against *A. dauci*. The reverse is true for zineb. Almost complete reversal in effectiveness is also apparent for ferbam against *Septoria apii* and *S. lycopersici* (Table 8). However, since these are distinct species, they might be expected to differ more in this respect than would forms of the same species.

It would appear impossible to use control data covering one species and to predict with any consistent degree of accuracy which type of fungicide would give best control of another species in the same genus. This conclusion is based on a reversal in effectiveness for zineb and ziram against *Alternaria dauci* and *A. solani*, as already noted, and against *Colletotrichum lindemuthianum* and *C. lagenarium*, and for ferbam against *Septoria apii* and *S. lycopersici*. However, if the writers had to choose a fungicide to control a new species in any of the four genera included in this survey with no time available for preliminary trials, they would select one of the two highest ranking types (Table 10). Such a choice should be more trustworthy than a random choice from among the more than 20 types of fungicides now available.

The degree of control with fungicides included in this survey (Table 9) agrees only in certain instances with the 1950 recommendations for disease control by pathologists in various States. For example, bordeaux mixture and the fixed coppers were predominant favorites (Table 11) for controlling most species of the four genera. Notable exceptions are *Alternaria*

brassicae (ziram), A. porri (zineb), Cercospora circumscissa (ferbam), C. cruenta and C. cruciferarum (ferbam), Colletotrichum gloeosporioides (ferbam and Bioquin 1), C. higginsianum (chloranil), C. phomoides (ziram), C. truncatum (zineb), and Septoria petroselini (zineb). It should be pointed out that in 1950 such materials as maneb, captan, zineb, and dichlone were hardly past the experimental stage in their commercial development.

There are several explanations for a lack of agreement between the calculated efficacy from the present survey and the actual recommendations:

1. Newer and seemingly more effective fungicides are seldom recommended in preference to well-established protectants until they have been shown to give better disease control over a wide range of conditions. A minimum of three to four years would appear to be required for such evaluations.

2. Often a complex of diseases is considered in making a recommendation for a specific disease. Thus one would sacrifice some control of Colletotrichum phomoides (tomato anthracnose) by recommending zineb over ziram but would expect better control of Stemphylium solani (gray leaf spot), Septoria lycopersici (Septoria leaf spot), and Phytophthora infestans (late blight). The same would probably be true also for diseases of potatoes and cucurbits.

3. Cost differentials are often important. Thus one might hesitate in recommending a new and relatively expensive fungicide when a well-established and cheaper chemical was available, particularly if the margin of control for the new material were not exceptional.

4. Phytotoxicity rather than fungicidal or protective value may be the deciding factor in determining whether a fungicide will be recommended for use on a specific crop. This is reflected in the obvious hesitancy of pathologists to recommend bordeaux mixture for controlling Colletotrichum lagenarium on cucumber (Table 11) although they have considered this fungicide satisfactory against the pathogen on other cucurbits.

5. Availability and ease of mixing or use may be considerations, though minor ones, in deciding which of two materials to recommend.

Since research data show that two pathologists in adjoining States working with several identical fungicides can seldom agree on the order of fungicidal effectiveness against a specific pathogen, it is remarkable -- and fortunate -- that pathologists can agree as well as they have on recommendations for specific diseases.

SUMMARY

From the reported data on disease control over the period 1942-1952, an evaluation was made of the comparative effectiveness of 17 types (33 formulations) of fungicides against 23 plant-pathogenic species in four genera of fungi. Disease control was the sole criterion with no consideration given to phytotoxicity, undesirable residues, or cost. A formula was developed for calculating the control-index for each fungicide. Four standards (zineb, ziram, fixed copper, and bordeaux mixtures) were used as comparisons.

Manzate was found to be a very effective fungicide against most species. The copper fungicides in general ranked higher than the organic compounds against Cercospora spp. and Septoria spp. but were relatively ineffective against Colletotrichum spp. Individual variations in response to fungicides were noted among species in the same genus. There were indications that form species, said to be alike culturally and morphologically but differing in pathogenicity, are dissimilar in response to fungicides. The calculated control efficiency ratings of the fungicides were not in complete agreement with recommendations current at the end of the survey period. Reasons are advanced to account for the apparent discrepancies.

Table 1. Plant-pathogenic species[a] and suscepts included in survey.

Species	Suscepts
Alternaria brassicae (Berk.) Sacc. and A. brassicicola (Schw.) Wiltsh.	Cabbage, cauliflower
A. cucumerina (Ell. & Ev.) J. A. Elliott	Cucurbits
A. tenuis Auct.	Petunia
A. porri (Ell.) Cif.[b]	Onion
A. panax Whet.	Ginseng
A. dauci (Kuehn) Groves & Skolko	Carrot
A. dianthi F. L. Stevens & J. G. Hall	Carnation
A. solani (Ell. & G. Martin) L. R. Jones & Grout[c]	Potato, tomato
Cercospora apii Fres.	Celery
C. beticola Sacc.	Beet
C. carotae (Pass.) Solh.	Carrot
Colletotrichum lindemuthianum (Sacc. & Magn.) Briosi & Cav.	Garden bean
C. phomoides (Sacc.) Chester[d]	Tomato
C. lagenarium (Pass.) Ell. & Halst.	Cucurbits
C. truncatum (Schw.) Andrus & W. D. Moore	Lima bean
C. higginsianum Sacc.	Chinese cabbage
C. antirrhini Stewart	Snapdragon
Septoria apii (Briosi & Cav.) Chester and S. apii-graveolentis Dorogin	Celery
S. lycopersici Speg.	Tomato
S. chrysanthemi Allesch.	Chrysanthemum
S. leucanthemi Sacc. & Speg.	Chrysanthemum

a Names are those given in "Index of Plant Diseases in the United States," compiled by Freeman Weiss and Muriel J. O'Brien, Plant Dis. Survey Spec. Publ. 1: pp. 1-1192; index part (Muriel J. O'Brien and John A. Stevenson): pp. 1195-1263. 1950-1953.

b Synonym: A. dauci (Kuehn) Groves & Skolko f. sp. porri (Ell.) Neergaard (41).

c Synonym: A. dauci (Kuehn) Groves & Skolko f. sp. solani (Ell. & G. Martin) Neergaard (41).

d The perfect stage has recently been found and named Glomerella phomoides (Sacc.) Swank; Phytopath. 43: 285-287. 1953.

Table 2. Names, active ingredients, classification and codes for fungicides included in survey[a].

Common or proprietary name	Active ingredients	Classification	Code (Tables 3-12)
1. Basicop	Basic copper sulfate	Fixed copper[d]	Fxc
2. Bioquin 1	Copper 8-quinolinolate	Organic copper	Bio 1
3. Bordeaux mixture	Unknown	Bordeaux[d]	Bordo
4. Copper A	Copper oxychloride	Fixed copper	Fxc
5. C-O-C-S	Copper oxychloride sulfate	Fixed copper	Fxc
6. Cop-O-Zink	Copper and zinc sulfates	Cop-O-Zink	C-O-Z
7. Copper-lime dust	Unknown	Bordeaux	Bordo
8. Crag 658	Copper zinc chromate	CuZn chromate	658
9. Dithane D-14 + $ZnSO_4$	Zinc ethylene bisdithiocarbamate	Zineb[d]	Zineb
10. Dithane D-14 + $ZnSO_4$ + lime	Zinc ethylene bisdithiocarbamate	Zineb[d]	Zineb

Table 2. (Continued).

Common or proprietary name	Active ingredients	Classification	Code (Tables 3-12)
11. Dithane Z-78	Zinc ethylene bisdithiocarbamate	Zineb	Zineb
12. Fermate	Ferric dimethyl dithiocarbamate	Ferbam	Ferbam
13. Karbam black	Ferric dimethyl dithiocarbamate	Ferbam	Ferbam
14. Karbam white	Zinc dimethyl dithiocarbamate	Ziram[d]	Ziram
15. Manzate or MnEBD	Manganese ethylene bisdithiocarbamate	Maneb	Maneb
16. Methasan, S or W	Zinc dimethyl dithiocarbamate	Ziram	Ziram
17. Orthocide 406 or SR-406	N-trichloromethyl-mercapto-4-cyclo-hexene-1, 2-dicarboxi-mide	Captan	Captan
18. Parzate (dry)	Zinc ethylene bisdithiocarbamate	Zineb	Zineb
19. Parzate (liquid) + $ZnSO_4$	Zinc ethylene bisdithiocarbamate	Zineb	Zineb
20. Phelps Dodge copper	Basic copper sulfate	Fixed copper	Fxc
21. Phygon or Phygon-XL	2, 3 dichloro-1, 4 naphthoquinone	Dichlone	Dichlone
22. Robertson copper	Metallic copper and cuprous oxide	Fixed copper	Fxc
23. Spergon (wettable)	Tetrachloro-para-benzoquinone	Chloranil	Chloranil
24. Spraycop	Basic copper sulfate	Fixed copper	Fxc
25. SDDC[b] + $FeSO_4$	Ferric dimethyl dithiocarbamate	Ferbam	Ferbam
26. SDDC[b] + $MnSO_4$	Manganese dimethyl dithiocarbamate	SDDC + $MnSO_4$	SDDC + Mn
27. Tennessee Tri-Basic $CuSO_4$	Basic copper sulfate	Fixed copper	Fxc
28. Tersan	Tetramethyl thiuram disulfide	Thiram	Thiram
29. Vancide 51 + $ZnSO_4$ (Vancide ZW)	(Na salts dimethyl dithiocarbamate) + $ZnSO_4$	Vancide ZW	Van ZW
30. Vancide 51 + $MnSO_4$	(and 2-mercapto-benzothiazole) + $MnSO_4$	Vancide MW	Van MW
31. Yellow Cuprocide	Cuprous oxide	Fixed copper	Fxc
32. Zac or Zac S	Zinc dimethyl dithiocarbamate-cyclohexylamine	Zac	Zac
33. Zerlate	Zinc dimethyl dithiocarbamate	Ziram	Ziram

[a] Crag 341, Tag 331, Isothan Q-15, Actidione, lime-sulfur, and sulfur were also used in a minority of tests but none is considered to be equal to the fungicides listed in Table 11 in protective value against the species concerned.

[b] Sodium dimethyl dithiocarbamate.

[c] Formerly identified as N-trichloromethylthio tetrahydrophthalimide.

[d] Two or more of these classes were used as standards in Tables 3-10.

Table 3. Control-indices of fungicides tested against *Alternaria brassicae*, *A. brassicicola* *A. cucumerina*, *A. tenuis*, *A. porri*, and *A. panax* (1942-52).

Evaluated fungicides	Control-indices of evaluated fungicides compared with standards				
	Zineb	Ziram	Fxc	Bordo	Total
			A. brassicae and *A. brassicicola*		
Zineb	--	33(6)	100(7)	--	69(13)
Ziram	67(7)[a]	--	83(6)	--	75(12)
Fxc	0(7)	17(6)	--	--	8(13)
Ferbam	0(3)	0(3)	100(5)	--	46(11)
Dichlone	0(1)	0(1)	0(1)	--	0(3)
658	0(1)	0(1)	75(2)	--	38(4)
Thiram	0(3)	0(3)	100(5)	--	46(11)
Chloranil	0(5)	0(4)	83(6)	--	33(15)
			A. cucumerina		
Zineb	--	61(22)	33(41)	11(14)	37(77)
Ziram	39(22)	--	39(18)	0(7)	33(47)
Fxc	67(41)	61(18)	--	23(11)	52(70)
Bordo	89(14)	100(7)	77(11)	--	88(32)
Maneb	0(2)	--	0(1)	0(1)	0(4)
Captan	100(1)	50(1)	100(2)	--	88(4)
Dichlone	17(3)	25(2)	25(2)	0(2)	17(9)
			A. tenuis		
Zineb	--	50(3)	--	100(1)	63(4)
Ziram	50(3)	--	--	0(1)	37(4)
Bordo	0(1)	100(1)	--	--	50(2)
Ferbam	0(2)	0(1)	--	--	0(3)
			A. porri		
Zineb	--	--	70(10)	33(3)	71(13)
Fxc	30(10)	--	--	0(1)	27(11)
Bordo	67(3)	--	100(1)	--	75(4)
Maneb	0(2)	--	0(3)	--	0(5)
Ferbam	50(1)	--	100(1)	0(1)	50(3)
			A. panax		
Fxc	--	--	--	0(4)	0(4)
Bordo	--	--	100(4)	--	100(4)
Ferbam	--	--	100(4)	0(1)	80(5)

[a] Numbers in parentheses indicate numbers of comparisons upon which indices are based.

Table 4. Control-indices of fungicides tested against Alternaria dauci, A. dianthi, and A. solani (1942-52).

Evaluated fungicide	Control-indices of evaluated fungicides compared with standards: Zineb	Ziram	Fxc	Bordo	Total
			A. dauci		
Zineb	--	29(14)	55(21)	60(5)	46(40)
Ziram	71(14)[a]	--	86(11)	100(2)	80(27)
Fxc	45(21)	14(11)	--	13(8)	30(40)
Bordo	40(5)	0(2)	87(8)	--	60(15)
Maneb	100(6)	67(3)	50(2)	--	82(11)
Ferbam	100(2)	--	100(5)	0(3)	70(10)
Captan	50(2)	0(2)	100(3)	100(1)	63(8)
658	100(4)	100(2)	50(2)	--	88(8)
Zac	50(2)	25(2)	100(3)	100(1)	79(8)
C-0-Z	0(3)	0(1)	0(1)	--	0(5)
Van ZW	33(3)	0(1)	0(1)	--	20(5)
			A. dianthi		
Zineb	--	83(9)	93(15)	50(6)	82(30)
Ziram	17(9)	--	86(7)	33(3)	45(19)
Fxc	7(15)	14(7)	--	0(5)	7(27)
Bordo	50(6)	67(3)	100(5)	--	73(14)
Maneb	0(1)	0(1)	--	0(1)	0(3)
Ferbam	0(2)	33(3)	--	0(1)	17(6)
Dichlone	11(9)	30(5)	0(7)	17(3)	13(24)
Van ZW	75(2)	100(2)	--	--	88(4)
			A. solani on potatoes		
Zineb	--	81(212)	93(318)	81(53)	88(583)
Ziram	19(212)	--	67(187)	55(23)	42(422)
Fxc	7(318)	33(187)	--	34(40)	18(545)
Bordo	19(53)	45(23)	66(40)	--	41(116)
Maneb	37(68)	38(38)	91(70)	100(6)	60(182)
Ferbam	0(2)	0(3)	67(3)	0(1)	22(9)
Captan	--	0(1)	--	100(1)	50(2)
Dichlone	0(18)	10(10)	34(12)	10(10)	15(50)
658	20(87)	62(42)	72(74)	61(14)	49(217)
Zac	20(50)	53(33)	70(37)	50(1)	45(121)
C-O-Z	15(62)	67(38)	80(54)	30(5)	50(159)
Van ZW	23(39)	35(31)	86(38)	100(1)	49(109)
Van MW	0(4)	0(5)	88(8)	--	41(17)
			A. solani on tomatoes		
Zineb	--	74(143)	59(168)	32(47)	70(358)
Ziram	26(143)	--	42((106)	21(26)	32(275)
Fxc	41(168)	58(106)	--	14(34)	41(308)
Bordo	68(47)	79(26)	86(34)	--	76(107)
Maneb	59(40)	79(27)	83(30)	50(4)	72(101)
Ferbam	18(19)	0(20)	22(9)	0(5)	10(53)
Captan	17(6)	50(6)	88(4)	--	28(16)
Dichlone	47(38)	47(16)	30(27)	18(11)	38(92)
658	34(56)	48(38)	30(55)	14(7)	37(156)
Zac	0(34)	26(39)	9(27)	0(2)	12(102)
C-O-Z	33(23)	68(19)	43(22)	0(3)	44(67)
Van ZW	21(7)	50(14)	87(6)	--	50(27)
Van MW	0(4)	0(8)	--	--	0(12)
SDDC + Mn	0(2)	50(4)	--	--	33(6)
Bio 1	37(8)	100(3)	50(4)	100(2)	59(17)

[a] Numbers in parentheses indicate numbers of comparisons upon which indices are based.

Table 5. Control-indices of fungicides tested against Cercospora apii, C. beticola, C. carotae (1942-52).

Evaluated fungicide	Control-indices of evaluated fungicides compared with standards				
	Zineb	Ziram	Fxc	Bordo	Total
			C. apii		
Zineb	--	45(50)	33(51)	33(12)	39(113)
Ziram	55(50)[a]	--	56(36)	36(7)	54(93)
Fxc	67(51)	44(36)	--	31(16)	53(103)
Bordo	67(12)	64(73)	69(16)	--	67(101)
Maneb	100(7)	25(4)	50(6)	0(1)	61(18)
Ferbam	52(12)	41(11)	41(17)	17(3)	45(43)
Captan	100(1)	50(2)	40(5)	0(1)	44(9)
Dichlone	20(10)	19(8)	12(13)	20(5)	17(36)
658	0(2)	0(2)	0(2)	--	0(6)
Zac	0(9)	10(10)	0(4)	50(1)	6(24)
C-O-Z	11(9)	0(7)	0(5)	--	5(21)
Chloranil	0(1)	0(2)	0(1)	--	0(4)
Bio 1	75(2)	0(1)	--	0(1)	37(4)
			C. beticola		
Zineb	--	--	0(2)	--	0(2)
Fxc	100(2)	--	--	--	100(2)
Ferbam	100(1)	--	0(2)	--	33(3)
			C. carotae		
Zineb	--	27(15)	56(18)	33(6)	39(39)
Ziram	73(15)	--	85(10)	67(30)	77(28)
Fxc	44(18)	15(10)	--	8(12)	23(40)
Bordo	67(6)	33(3)	92(12)	--	76(21)
Maneb	100(5)	67(3)	50(2)	--	80(10)
Ferbam	100(2)	--	100(9)	0(4)	73(15)
Captan	50(2)	0(2)	100(3)	100(1)	63(8)
Dichlone	0(2)	0(1)	--	0(1)	0(4)
658	100(3)	100(1)	0(2)	--	67(6)
Zac	50(2)	25(2)	100(3)	100(1)	69(8)
C-O-Z	0(3)	--	0(1)	--	0(4)
Van ZW	33(3)	0(1)	0(1)	--	20(5)

[a] Numbers in parentheses indicate numbers of comparisons upon which indices are based.

Table 6. Control-indices of fungicides tested against Colletotrichum lindemuthianum, C. phomoides and C. lagenarium (1942-52).

Evaluated fungicides	Control-indices of evaluated fungicides compared with standards				
	Zineb	Ziram	Fxc	Bordo	Total
			C. lindemuthianum		
Zineb	--	0(3)	100(1)	33(3)	28(7)
Ziram	100(3)[a]	--	--	100(3)	100(6)
Fxc	0(1)	--	--	0(1)	0(2)
Bordo	67(3)	0(3)	100(1)	--	43(7)
Ferbam	33(6)	0(3)	100(1)	67(3)	38(13)
Dichlone	67(3)	--	100(1)	--	75(4)
			C. phomoides		
Zineb	--	29(184)	82(153)	61(38)	55(375)
Ziram	71(184)	--	92(111)	88(21)	80(316)
Fxc	18(153)	8(111)	--	25(26)	15(290)
Bordo	29(38)	12(21)	75(26)	--	35(85)
Maneb	72(46)	85(33)	96(24)	--	82(103)
Ferbam	42(19)	11(27)	94(11)	57(7)	43(64)
Captan	62(13)	79(7)	100(8)	--	77(28)
Dichlone	19(16)	11(9)	7(10)	8(12)	28(47)
658	20(45)	9(37)	45(41)	0(2)	24(125)
Zac	70(46)	32(47)	87(30)	100(2)	67(125)
C-O-Z	0(23)	5(22)	39(14)	--	19(59)
Van ZW	0(10)	37(12)	40(5)	--	24(27)
Van MW	0(6)	0(8)	--	--	0(14)
SDDC+Mn	0(2)	50(4)	--	--	33(6)
Bio 1	40(5)	0(2)	100(1)	100(2)	50(10)
			C. lagenarium		
Zineb	--	78(12)	96(24)	87(4)	90(40)
Ziram	22(12)	--	65(10)	50(2)	42(24)
Fxc	4(24)	35(10)	--	25(4)	14(38)
Bordo	13(4)	50(2)	75(4)	--	45(10)
Maneb	63(4)	100(3)	100(1)	--	81(8)
Ferbam	37(19)	50(5)	68(14)	67(3)	51(41)
Captan	40(10)	100(1)	100(5)	--	63(16)
Dichlone	0(2)	--	100(1)	--	33(3)
658	10(10)	33(3)	60(6)	--	28(19)
Zac	0(2)	0(1)	0(2)	--	0(5)
C-O-Z	0(4)	--	75(2)	--	25(6)
Van ZW	0(2)	0(2)	--	--	0(4)

[a] Numbers in parentheses indicate numbers of comparisons upon which indices are based.

Table 7. Control-indices of fungicides tested against *Colletotrichum truncatum*, *C. higginsianum* and *C. antirrhini*.

Evaluated fungicides	Control-indices of evaluated fungicides compared with standards				
	Zineb	Ziram	Fxc	Bordo	Total
			C. truncatum		
Zineb	--	100(3)	100(1)	--	100(4)
Ziram	0(3)[a]	--	0(1)	--	0(4)
Fxc	0(1)	100(1)	--	--	50(2)
Ferbam	0(2)	100(2)	0(1)	--	40(6)
Dichlone	67(3)	100(3)	100(1)	--	86(7)
			C. higginsianum		
Zineb	--	75(4)	--	--	75(4)
Ziram	25(4)	--	--	--	25(4)
Ferbam	0(2)	50(2)	--	--	25(4)
Chloranil	67(3)	67(3)	--	--	67(6)
			C. antirrhini		
Zineb	--	--	--	100(1)	100(1)
Bordo	0(1)	--	--	--	0(1)
Ferbam	0(1)	--	--	--	0(1)

[a] Numbers in parentheses indicate numbers of comparisons upon which indices are based.

Table 8. Control-indices of fungicides tested against *Septoria apii*, *S. apii-graveolentis*, *S. chrysanthemi*, *S. leucanthemi* and *S. lycopersici* (1942-52).

Evaluated fungicides	Control-indices of evaluated fungicides compared with standards				
	Zineb	Ziram	Fxc	Bordo	Total
			S. apii and *S. apii-graveolentis*		
Zineb	--	50(4)	0(5)	0(1)	20(10)
Ziram	50(4)[a]	--	30(5)	--	39(9)
Fxc	100(5)	70(5)	--	50(5)	71(15)
Bordo	100(1)	--	50(5)	--	58(6)
Ferbam	100(1)	--	100(6)	100(3)	100(10)
Dichlone	50(4)	50(1)	25(2)	--	43(7)
			S. chrysanthemi		
Zineb	--	50(1)	--	--	50(1)
Ziram	50(1)	--	--	--	50(1)
Fxc	50(1)	--	--	0(2)	35(3)
Bordo	--	--	100(2)	--	100(2)
Maneb	50(3)	--	--	--	50(3)
Ferbam	50(3)	50(1)	100(2)	100(1)	72(7)
Captan	50(2)	--	--	--	50(2)
Dichlone	50(1)	50(1)	--	--	50(2)
Zac	0(1)	--	--	--	0(1)
Van ZW	50(1)	50(1)	--	--	50(2)
Bio 1	50(1)	--	--	--	50(1)
			S. leucanthemi		
Zineb	--	--	0(1)	--	0(1)
Fxc	100(1)	--	--	--	100(1)
Van ZW	100(1)	--	50(1)	--	75(2)
			S. lycopersici		
Zineb	--	75(8)	52(23)	39(9)	54(40)
Ziram	25(8)	--	6(8)	25(4)	18(20)
Fxc	48(23)	94(8)	--	69(8)	62(39)
Bordo	61(9)	75(4)	31(8)	--	53(21)
Maneb	32(17)	50(1)	80(10)	33(6)	48(34)
Ferbam	25(2)	0(1)	0(4)	50(3)	20(10)
Captan	13(8)	--	50(4)	0(1)	28(13)
Dichlone	50(10)	70(5)	32(11)	42(6)	45(32)
658	50(2)	100(1)	0(3)	0(2)	25(8)
C-O-Z	100(1)	100(1)	100(2)	--	100(4)
Van ZW	0(2)	--	--	--	0(2)
Van MW	0(2)	--	--	--	0(2)
Chloranil	0(2)	0(1)	0(3)	25(2)	6(8)

[a] Numbers in parentheses indicate numbers of comparisons upon which indices are based.

Table 9. Summary of degree of control with fungicides of 23 pathogens based on indices in Tables 3 and 8. Possible phytotoxicity and undesirable residues not considered (1942-52).

Pathogen	Fungicides: Moderate to good control	Fungicides: Promising[a]
Alternaria brassicae[b]	Ziram, Zineb	Captan, Maneb, Zac, Van ZW
A. cucumerina	Captan[c], Bordo, Fxc	Maneb, Zac, Van ZW, 658, Ferbam
A. tenuis	Zineb[c] Bordo[c]	Zac, Van ZW, 658, Captan, Maneb
A. porri	Bordo[c], Zineb	Captan, 658, Zac, Van ZW, Maneb, Ziram
A. panax	Bordo[c], Ferbam[c]	Captan, 658, Zac, Van ZW, Maneb, Ziram, Zineb
A. dauci	658[c], Maneb, Ziram, Zac[c], Ferbam	Captan, Van ZW
A. dianthi	Van ZW[c], Zineb, Bordo	Maneb, Captan, 658, Zac
A. solani on potatoes	Zineb, Maneb	Captan
A. solani on tomatoes	Bordo, Maneb, Zineb	
Cercospora apii	Bordo, Maneb, Ziram, Fxc	Captan, 658
C. beticola	Fxc	Maneb, Ziram, Captan, 658, Zac
C. carotae	Maneb, Ziram, Bordo	Captan, 658, Zac
Colletotrichum lindemuthianum	Ziram[c], Dichlone[c]	Maneb, Captan, Zac
C. phomoides	Maneb, Ziram, Captan, Zac, Zineb	
C. lagenarium	Zineb, Maneb[c]	Dichlone, Zac, Van ZW
C. truncatum	Zineb[c], Dichlone[c]	Maneb, Ziram, Captan, Zac, Van ZW
C. higginsianum	Zineb[c], Chloranil[c]	Maneb, Captan, Dichlone, Zac, Van ZW, Ziram
C. antirrhini	Zineb[c]	Maneb, Ziram, Captan, Dichlone, Zac, Van ZW
Septoria apii[d]	Ferbam, Fxc, Bordo[c]	Maneb, Dichlone, Van ZW, C-O-Z
S. lycopersici	C-O-Z[c], Fxc, Zineb, Bordo, Maneb, Dichlone	Van ZW
S. chrysanthemi	Bordo[c], Ferbam[c]	Maneb, Dichlone, Van ZW, C-O-Z, Zineb, Fxc
S. leucanthemi	Fxc[c], Van ZW[c]	Maneb, Dichlone, C-O-Z, Zineb, Ferbam

[a] Indicates need for testing or retesting based on performance against this or other species in genus.

[b] Includes A. brassicicola.

[c] Based on less than 10 comparisons with standards.

[d] Includes S. apii-graveolentis.

Table 10. Summary of control-indices of fungicides aginst the genera Alternaria, Cercospora, Colletotrichum, and Septoria, with order based solely on indices in Tables 3-8.

Genera, evaluated fungicides and total control-indices							
Alternaria spp.		Cercospora spp.		Colletotrichum spp.		Septoria spp.	
Zineb	76(118)[a]	Bordo	71(122)	Maneb	82(111)	C-O-Z	100(4)
Maneb	62(306)	Maneb	70(28)	Ziram	76(354)	Fxc	63(57)
Bordo	62(294)	Ziram	59(121)	Captan	72(44)	Ferbam	63(27)
Bio 1	59(17)	Captan	53(17)	Chloranil	67(6)	Bordo	57(29)
Van ZW	49(145)	Ferbam	51(61)	Zineb	59(431)	Bio 1	50(1)
C-O-Z	47(231)	Fxc	47(145)	Zac	58(130)	Maneb	49(37)
Captan	47(30)	Zineb	38(154)	Bio 1	50(10)	Zineb	46(52)
Ziram	46(806)	Bio 1	37(4)	Ferbam	44(129)	Dichlone	45(41)
Thiram	46(11)	658	33(12)	Dichlone	39(61)	Van ZW	42(6)
658	44(385)	Zac	24(32)	Bordo	36(103)	Captan	32(15)
Chloranil	33(15)	Van ZW	20(5)	SDDC+Mn	33(6)	Ziram	25(30)
SDDC+Mn	33(6)	Dichlone	15(40)	658	25(144)	658	25(8)
Zac	31(231)	C-O-Z	4(25)	Van ZW	21(31)	Chloranil	13(8)
Ferbam	30(100)	Chloranil	0(4)	Fxc	15(332)	Van ZW	0(2)
Fxc	26(1018)			C-O-Z	11(65)	Zac	0(1)
Dichlone	26(178)			Van MW	0(14)		
Van MW	24(29)						

a Numbers in parentheses indicate numbers of comparisons upon which indices are based.

Table 11. Summary of fungicides recommended[a] for control of species of Alternaria, Cercospora, Colletotrichum and Septoria by pathologists in various states. 1950.

Pathogen	Crop	No. of times fungicide given as 1st choice							
		Bordo	Fxc	Ferbam	Ziram	Zineb	Bio 1	Chloranil	Dichlone
Alternaria brassicae	Cabbage	1	1	--	2	--	--	1	--
	Cauliflower	1	1	--	1	--	--	1	--
	Broccoli	--	1	--	2	--	--	1	--
	Brussels Sprouts	1	1	1	2	--	--	1	--
	Kohlrabi	--	1	--	--	--	--	1	--
	Collards	--	1	--	--	--	--	1	--
	Horseradish	1	--	--	--	--	--	--	--
A. cucumerina	Squash & Pumpkin	4	6	--	1	2	--	--	--
	Cantaloupe	1	--	--	--	--	--	--	--
	Watermelon	1	--	--	--	--	--	--	--
A. porri	Onion	1	--	--	--	2	--	--	--
A. solani	Potato	16	2	--	3	8	--	--	--
	Tomato	8	9	--	6	4	--	--	--
	Eggplant	1	--	--	--	--	--	--	--
Alternaria spp. (Total)		36	23	1	17	16	--	6	--

Table 11. (Continued).

Pathogen	Crop	No. of times fungicide given as 1st choice: Bordo	Fxc	Ferbam	Ziram	Zineb	Bio 1	Chloranil	Dichlone
Cercospora apii	Celery	10	2	--	--	2	--	--	--
C. aurantia	Citrus	1	--	--	--	--	--	--	--
C. beticola	Beet	4	--	--	--	--	--	--	--
	Spinach	1	--	--	--	--	--	--	--
	Swiss Chard	--	--	--	--	1	--	--	--
C. capsici	Pepper	6	4	1	--	2	--	--	--
C. circumscissa	Cherry	--	--	2	--	--	--	--	--
C. citrullina	Watermelon	1	--	--	--	--	--	--	--
C. cruenta	Snap Bean	--	--	1	--	--	--	--	--
C. cruciferarum	Radish	--	--	1	--	--	--	--	--
C. fici	Fig	1	--	--	--	--	--	--	--
C. mali	Apple	1	--	--	--	--	--	--	--
C. obscura	Artichoke	1	--	--	--	--	--	--	--
C. purpurea	Avocado	--	1	--	--	--	--	--	--
C. rubi	Blackberry	1	--	--	--	--	--	--	--
C. viticola	Grape	1	--	--	--	--	--	--	--
Cercospora spp. (Total)		28	7	5	--	5	--	--	--
Colletotrichum	Citrus								
gloeosporioides	Citrus	1	--	--	--	--	--	--	--
	Guava	--	--	1	--	--	--	--	--
	Mango	--	--	--	--	--	1	--	--
	Papaya	--	--	1	--	--	--	--	--
C. gossypii[b]	Date Palm	1	--	--	--	--	--	--	--
C. higginsianum	Turnip	--	--	--	--	--	--	1	--
C. lagenarium	Cucumber	1	5	--	4	2	--	--	--
	Muskmelon	6	4	--	4	3	--	--	--
	Squash & Pumpkin	1	--	--	--	--	--	--	--
	Watermelon	7	6	1	2	--	--	--	--
C. phomoides	Tomato	--	2	--	15	2	--	--	--
C. lindemuthianum	Snap Bean	4	--	2	--	2	--	--	1
C. truncatum	Lima Bean	1	--	--	--	2	--	--	--
Colletotrichum spp. (Total)		22	17	5	25	11	1	1	1
Septoria apii	Celery	8	1	--	1	1	--	--	--
S. lycopersici	Tomato	9	10	--	--	4	--	--	--
S. petroselini	Parsley	--	--	--	--	1	--	--	--
S. rubi	Raspberry	4	--	2	--	--	--	--	--
Septoria spp. (Total)		21	11	2	1	6	--	--	--

[a] Compiled from "The control of fruit and vegetable diseases" by G. L. McNew, S. F. A. McCallan and P. R. Miller, 1951. Boyce Thompson Inst. Reprint 694: 61 pp. (Tables 13-61).

[b] *Colletotrichum gloeosporioides* (?).

Selected References

1. American Phytopathological Society, Sub-committee on "Summation of the performance of newer fungicides." 1948. 1947 fungicide tests. Plant Dis. Reptr. Suppl. 176. (Mimeogr.)
2. ______________________. 1948. Report of the special committee on the coordination of field tests with new fungicidal sprays and dusts, with reference to results obtained in 1947. Plant Dis. Reptr. Suppl. 174. (Mimeogr.)
3. ______________________. Sub-committee on "Summation of the performance of newer fungicides." 1949. Nation-wide results with fungicides in 1948. Fourth annual report. Plant Dis. Reptr. Suppl. 181. (Mimeogr.)
4. ______________________. 1949. Second annual report of the special committee of the American Phytopathological Society on the coordination of field tests with new fungicidal sprays and dusts, with reference to the results obtained in 1948. Plant Dis. Reptr. Suppl. 183. (Mimeogr.)
5. ______________________. 1950. Third annual report of the special committee of the American Phytopathological Society on the coordination of field tests with fungicidal sprays and dusts, with reference to the results obtained in 1949. (Mimeogr.)
6. ______________________. Sub-committee on testing and results of newer fungicides. 1950. Nation-wide results with fungicides in 1949. Fifth annual report. Plant Dis. Reptr. Suppl. 192.
7. ______________________. Sub-committee on testing and results of newer fungicides. 1952. 1950 summary of results of fungicide tests on crops other than fruit trees. Plant Dis. Reptr. Suppl. 210.
8. ______________________. Sub-committee on testing and results of newer fungicides. 1952. 1951 summary of results of fungicide tests in the United States and Canada. Plant Dis. Reptr. Suppl. 213.
9. ______________________. Advisory committee on collecting and disseminating data on new fungicide tests. 1954. Results of 1953 fungicide tests. Agr. Chem. 9 Nos. 1, 2, 3.
10. Beach, W. S. 1950. Tomato spraying in Pennsylvania. Pennsylvania Agr. Exp. Sta. Bul. 531.
11. Borders, H. I. 1951. Tests of fungicides for the control of tomato plant diseases in South Georgia, 1949-50. Plant Dis. Reptr. 35: 98-101.
12. Cox, R. C. 1948. Stem anthracnose on lima beans and its control (Abs.) Phytopath 38: 7.
13. ________. 1949. Further studies on stem anthracnose on lima beans in North Carolina. (Abs.) Phytopath 39: 5.
14. ________. 1950. Stem anthracnose on lima beans. North Carolina Agr. Exp. Sta. Tech. Bul. 90.
15. Dimock, A. W. 1943. Coming up-to-date on Verticillium wilt and Septoria leaf spot on chrysanthemum. Amer. Chrysanth. Soc. Bul. 11 (1): 3-10.
16. __________. 1946. Disease control on chrysanthemum stock plants. American Chrysanth. Soc. Bul. 14 (1): 14-18.
17. __________. 1947. Diseases in commercial flower production can be controlled. Flor. Exch. and Hort. Trade World 108 (23): 17, 36, 53.
18. __________. 1948. Chrysanthemum and carnation disease control. Flor. Exch. and Hort. Trade World 111 (23): 18, 59-61.
19. __________. 1948. Parzate. New York State Flower Growers Bul. 31: 8.
20. __________. and H. Allyn. 1944. Dipping rooted chrysanthemum cuttings in Fermate for Septoria leaf spot. Amer. Chrysanth. Soc. Bul. 12 (2): 9-11.
21. Eddins, A. H. 1948. Alternaria leaf spot of cabbage and other crucifers. Florida Agr. Exp. Sta. Ann. Rept. 1948: 111-113.
22. __________, and J. W. Wilson. 1948. Cercospora blight of celery. Florida Agr. Exp. Sta. Ann. Rept. 1948: 140.

23. Foster, A. A. 1947. Alternaria leaf spot of cabbage and other crucifers. Florida Agr. Expt. Sta. Ann. Rept. 1947: 142.

24. __________. 1947. Early blight of celery. Florida Agr. Exp. Sta. Ann. Rept. 1947: 140.

25. Godfrey, G. H. 1945. Onion leaf blotch reduced by spraying. Plant Dis. Reptr. 29: 652-654.

26. Hendrix, J. W., M. Matsuura, and K. Kikuta. Fungicide investigations. Hawaiian Agr. Exp. Sta. Bienn. Rept. 1944-46: 104-107.

27. Heuberger, J. W. 1947. Suggestions on planning tomato disease control programs. Food Packer and Canning Age 28 (7): 59-61.

28. __________. 1951. Eight years of Dithane vs. copper on potatoes in Delaware. (Abs.). Phytopath. 41: 561-562.

29. __________, S. H. Davis, Jr., L. P. Nichols, and L. D. Beuhler. 1947. Zinc ethylene bisdithiocarbamate as a fungicide on vegetables. (Abs.). Phytopath. 37: 9.

30. __________, and L. A. Stearns. 1947. New organic fungicides and insecticides for potatoes. (Abs.). Phytopath. 37: 9.

31. __________, and D. O. Wolfenbarger. 1944. Zinc dimethyl dithiocarbamate and the control of early blight and anthracnose on tomatoes and of leafhoppers and early blight on potatoes. (Abs.). Phytopath. 34: 1003.

32. Horsfall, J. G. 1945. Fungicides and their action. p. 50, Chronica Botanica Co., Waltham, Mass.

33. Linn, M. B., and R. G. Emge. 1949. Development of anthracnose and secondary rots in stored tomato fruits in relation to field spraying with fungicides. Phytopath. 39: 898-906.

34. Lyle, J. A., snd J. W. Hendrix. 1949. Control of tomato diseases. Hawaiian Agr. Exp. Sta. Bienn. Rept. 1946-48: 117.

35. McClean, D. M., and D. H. Bjornseth. 1947. Control of anthracnose on cannery tomatoes -- two years results. Michigan Agr. Exp. Sta. Quart. Bul. 28 (4): 287-293.

36. __________, and __________. 1943. IX. Effect of different fungicides on leaf blight and yield of tomatoes. The Canner 96 (15): 12-14, 24, 26, 28.

37. __________, and __________. 1943. XII. The control of anthracnose on cannery tomatoes. The Canner 96 (18): 16, 17, 26-28.

38. McNew, G. L. 1944. Bean anthracnose checked by new spray. Farm Res. 10: 19.

39. Muncie, J. H., M. R. Hatfield, and S. F. Morofsky. 1949. Field tests of new potato fungicides. Michigan Agr. Exp. Sta. Quart. Bul. 32: 275-278.

40. Nagel, C. M., and L. T. Richardson. 1951. Tomato leaf spot control. South Dakota Agr. Exp. Sta. Cir. 91.

41. Neergaard, P. 1945. Danish species of _Alternaria_ and _Stemphylium_, 560 pp. Copenhagen.

42. Nelson, Ray. 1949. Control of celery early blight in 1948 and 1949. Michigan Agr. Exp. Sta. Quart. Bul. 32: 562-574.

43. Parris, G. K. 1948. Watermelon disease control. Florida State Hort. Soc. Proc. 1947: 147-150.

44. __________. 1950. Recent advances in watermelon disease control. Florida State Hort. Soc. Proc. 1949: 146-150.

45. __________, and L. H. Stoner. 1948. Spraying for disease control in Florida. Florida State Hort. Soc. Proc. 1947: 93-94.

46. Reddy, C. S. 1950. Breeding and selection of better resistant strains of melons. Iowa Agr. Exp. Sta. Ann. Rept. 1949: 162-163.

47. Reid, W. P., and R. M. Brein. 1948. Control of anthracnose on dwarf beans. New Zealand Jour. Sci. Tech. 29A (6): 304-306.

48. Scheffer, R. P. 1950. Anthracnose of crucifers. North Carolina Agr. Exp. Sta. Tech. Bul. 92.

49. Stoddard, D. L. 1949. Early blight of celery. Florida Agr. Exp. Sta. Ann. Rept. 1948-49: 209-212.

50. Strong, M. C. 1949. Comparison of fungicidal sprays for control of tomato blights. Michgian Agr. Exp. Sta. Quart. Bul. 32: 338-347.
51. Vaughn, E. K. 1952. Control of celery late blight. (Abst.). Phytopath. 42: 519.
52. Walker, W. W., and G. E. Weber (Revised by G. K. Parris). 1949. Diseases of watermelons in Florida. Florida Agr. Exp. Sta. Bul. 459.
53. Walter, J. M., D. G. A. Kelbert, and J. R. Beckenbush. 1949. Organic fungicides for the control of foliage diseases of vegetables. Florida Agr. Exp. Sta. Ann. Rept. 1948: 125-128.
54. Wellman, F. L. 1949. Successful spray control of Alternaria blight of petunias grown for seed in Costa Rica. Plant Dis. Reptr. 33: 69-72.
55. Wilson, J. D. 1943. Preliminary results on the control of tomato anthracnose. Ohio Agr. Exp. Sta. Bimo. Bul. 28: 34-37.
56. ____________. 1944. Further observations on the control of tomato anthracnose. Ohio Agr. Exp. Sta. Bimo. Bul. 29: 56-63.
57. ____________. 1944. Organic fungicides and the control of vegetable diseases in Ohio. Ohio Agr. Exp. Sta. Bimo. Bul. 30: 49-61.
58. ____________. 1944. Ten years of carrot spraying with various copper containing materials. Ohio Agr. Exp. Sta. Bimo. Bul. 29: 63-74.
59. ____________. 1944. The control of celery blights with bordeaux, the fixed coppers with and without sulfur, and fermate. Ohio Agr. Exp. Sta. Bimo. Bul. 29: 94-110.
60. ____________. 1949. Summary of vegetable disease control experiments conducted in Ohio in 1949. Ohio Agr. Exp. Sta., Botany Mimeo. Pub. No. 8.
61. ____________. 1951. A summary of the vegetable disease control experiments conducted in Ohio in 1950. Ohio Agr. Exp. Sta. , Botany Mimeo. No. 10.
62. ____________. 1952. Tomato experiments at Stryker in 1951. Suppl. to Ohio Agr. Exp. Sta. Botany Mimeo. No. 10.
63. ____________. 1952. Vegetable disease control experiments in Ohio in 1951. Ohio Agr. Exp. Sta. Botany Mimeo. No. 13.
64. ____________. 1953. A summary of disease control experiments in Ohio in 1952. Ohio Agr. Exp. Sta. Botany Mimeo. No. 14.
65. ____________, and H. A. Runnels. 1945. Comparative ability of the fixed coppers to control ginseng blight. Ohio Agr. Exp. Sta. Bimo. Bul. 29: 135-144.
66. ____________, and ______________. 1945. A comparison of various carbamates for the control of bean anthracnose. Ohio Agr. Exp. Sta. Bimo. Bul. 30: 189-191.
67. ____________, and H. C. Young. 1945. Comparison of various fungicides, diluents, and adhesives in controlling Cercospora leaf spot of sugar beets. Ohio Agr. Exp. Sta. Bimo. Bul. 30: 62-73.
68. Wilson, J. W. 1950. Cercospora blight of celery. Florida Agr. Exp. Sta. Ann. Rept. 1949: 172.

UNIVERSITY OF ILLINOIS, URBANA

THE PLANT DISEASE REPORTER

Issued By

PLANT DISEASE EPIDEMICS
and
IDENTIFICATION SECTION

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

NEW DEVELOPMENTS AND NEW PROBLEMS CONCERNING NEMATODES IN THE SOUTH

Supplement 227 October 15, 1954

The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Plant Disease Epidemics and Identification Section serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

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Horticultural Crops Research Branch   Plant Industry Station, Beltsville, Maryland

Papers From The Symposium On

NEW DEVELOPMENTS AND NEW PROBLEMS CONCERNING NEMATODES IN THE SOUTH

presented at the Dallas meeting
Southern Division, American Phytopathological Society
Dallas, Texas, February 1-3, 1954

Plant Disease Reporter
Supplement 227   October 15, 1954

CONTENTS

PLANT NEMATOLOGY: SCIENCE OR SERVICE?

Eldon J. Cairns

Confronting the at present relatively few plant nematologists is a dilemma that should be recognized by all concerned with plant nematodes. The phytonematologist finds that increased requests for more research and for more service create a predicament for him. If he devotes most of his time to the service demands, it is at the expense of his own research. Service work does render valuable assistance to the research activities of others, aids plant growers, and promotes interest in and support for Plant Nematology. If, on the other hand, the nematologist devotes most of his time to the pressing research problems, for which he is specially trained, he does so at the expense of the service requests.

In the past, the dilemma of "Plant Nematology: Science or Service?" has been resolved by compromise, with a strong tendency towards service. This course of action is probably the major reason for the increased awareness of the importance of plant nematodes as an adverse factor in plant production. Service work has made it possible for the few plant nematologists to gain a practical evaluation of the nematode situation on a national and, to some extent, international scale. Service work is of great value in obtaining knowledge as to the distribution of species and the development of epidemics and leads to the discovery of new forms. Service work to regulatory agencies gives definite information on the modes and extent of dispersal of nematodes as the result of man's activities. Service work also enables the nematologist to keep in touch with the associations of nematodes with plant disorders wherever plants are grown for pleasure or profit.

The present-day situation is intensifying the dilemma. There is the same, but increasing, service responsibility as more growers and allied research workers become concerned with nematodes. In addition, there is now an increasing obligation to do research. This has come with the admission that appreciable further progress in plant nematode control is dependent upon more research. Any compromise solution of the nematologist's dilemma has now to provide for the needed science.

Obviously, the ideal condition is "Plant Nematology: Science and Service"; it cannot be simply one or the other. However, to the person confronted with the increasing demands for Science and Service, whether he can do both well is becoming an issue. But is it realized that the decision is a matter of concern and is, in part, dependent upon the growers and research workers of the Southern Region? The answer is yes, because the Southern Regional Nematode Project is an outcome of the recognition by these groups of the nematode problems. Under this Regional Project nematode research centers were recently established at Raleigh, North Carolina and at Auburn, Alabama. The nematologists starting these centers face the problem of developing a high output of both Science and Service.

The phytonematologist recognizes the need for giving service and understands its value in assisting the research of others working with nematodes; he is desirous of continuing it as a part of his job. At the same time he is aware of the needed basic research to which he wants to contribute. Furthermore, the nematologist appreciates the sometimes overlooked fact that the service he renders others can be no wider in scope or more valuable than its scientific basis. For example, a routine service diagnosis is no better than the accuracy of the identification and the adequacy of the sample. Furthermore, an identification is of little value unless it can be put to use. Plant Nematology as a Service will become more worthwhile when, after examining representative samples, we can better answer such questions as the following: Are the nematodes involved able to cause plant losses? Which kinds of plants will suffer and to what extent? What will be the chances of finding a resistant crop variety? What will be the influence of such ecological factors as location, climate, soil type and condition, and the associated soil microorganisms? The nematologist does not want to avoid giving Service. However, he is concerned by the realization that the same amount of routine work could produce greater value if the foundation of scientific knowledge were more extensive.

How can the nematologist's dilemma be resolved so that he can conduct needed basic research without drastically reducing service? Seemingly a realistic solution involves the cooperation of those requesting service and the training of more workers in nematology.

At present, the nematologist must have more time for research. How can he get it? The most frequent and probably the most time consuming type of service request is for identification of nematodes in soil and plant samples. Considerable time could be saved if the samples sent to the nematologist arrived in better condition and were more representative. Such samples are easier to process and will yield more information. Soil and plant samples are best when col-

lected and shipped in moisture-proof wrappings such as plastic or waxed-lined bags. A composite of several samplings will be more representative than a single sample. Remember, too, that active, motile nematodes, if obligate parasites, will have left host tissues showing obvious necrosis.

In the future, time for research would be increased if more people were trained in the methods of nematology. Many persons, if instructed, would be able to do some of their own nematode service work. Some workers have been doing it, and all who learn to examine their plant material and identify the nematodes present will find it an advantage in their research. No involved or lengthy training is needed for any interested person to become competent in using the relatively few and simple techniques of plant nematology. In the near future instructional aids such as manuals, simpler generic keys, and possibly occasional short courses in practical nematology should be made available. Special efforts should be made to provide advanced training for those who want to specialize. At present, some graduate course work in plant nematology is available at North Carolina State College of Agriculture and Engineering and at the University of California. Another possibility which has been successfully operating for the Section of Nematology of the United States Department of Agriculture is on-the-job training with the cooperation of nearby universities. Having more people trained in plant nematology can be of such great mutual benefit that providing opportunities for training should become a recognized part of any Regional Nematode Project.

NEMATOLOGY SECTION

NEMATODES AS POSSIBLE MEMBERS OF DISEASE COMPLEXES INVOLVING OTHER PLANT PATHOGENS

Q. L. Holdeman

A survey of the literature reveals numerous reports on the association of nematodes with the increased severity of diseases attributed to other causes. Most of these reports are based on observations and on indirect approaches to the problem. Very little has been published on experiments that would definitely demonstrate the influence of nematodes. New advances in techniques offer an opportunity to study and to demonstrate a definite relationship, if any. A brief summary of the problem at this time may serve to point out needed research.

COTTON -- Fusarium Wilt. As early as 1892, Atkinson (3) in Alabama reported that root knot and wilt (Fusarium oxysporum f. vasinfectum) were distinct diseases, but when both attacked the plant, the condition of the plant was much more serious.

In the late twenties and early thirties when wilt-resistant varieties of upland cottons were released and grown in widely scattered locations, it was found that varieties were resistant in one location but might show a high percentage of wilt in another. Again, the attention was focused on nematodes. The nematodes that have been reported associated with the occurrence of severe wilt include root knot (Meloidogyne sp.), meadow (Pratylenchus (?) pratensis), and the sting nematodes (Belonolaimus gracilis).

The use of nematocides added evidence to the role of the nematodes. It was observed that fumigation of the soil to control nematodes reduced the incidence of Fusarium wilt on resistant varieties.

In 1941, Smith pointed out that cotton varieties combining root knot and wilt resistance were required for Coastal Plains conditions. More recently, Smith and Dick (15) reported that resistance in upland cotton to Fusarium wilt is apparently determined by a single dominant factor. The ability of a variety to survive in the field would depend largely on the number of factors for nematode resistance inherent in the variety.

Although circumstantial evidence was strong, definite laboratory demonstration of the role of nematodes has only recently been presented. Although Arndt and Christie (1) obtained negative results with their greenhouse experiments involving four free-living nematodes, Holdeman and Graham (8) were able to demonstrate a relationship between the sting nematode and the increased incidence of wilt on a wilt-resistant cotton. To date, the relationship of root knot and meadow nematodes to the increased severity of wilt has not been demonstrated.

The nematodes' mode of action in increasing the severity of wilt is not fully understood. It has been mentioned that root knot larvae macerate the root tips and cause cracks that extend into the differentiating tissue, thus offering a portal of entry. In some instances, nematodes inject salivary secretions into the root cells, probably causing some damage other than mechanical penetration of the cells.

The effect of nematode damage to the root system on the uptake of nutrients should be considered. In some non-fertile fields, it has been demonstrated that the application of potash to the soil reduced the amount of wilt (21). It is of interest to note that Oteifa (12), working with Lima bean, was able to overcome some of the growth reduction caused by the root knot nematode (M. incognita) by increasing the amount of potassium in his nutrient solutions.

In their experiments with the sting nematode, Holdeman and Graham observed that surviving plants of both wilt-resistant and of susceptible cottons usually had one or more roots that "escaped" to the side or to the bottom of the pot and developed normally. This suggests that the increased incidence of wilt was probably due to the severity of the damage and to the ability of the nematode to eliminate the effective root system.

Under field conditions where nematodes are the main factor, the wilt can be controlled without rotation by combining soil fumigation with the use of a resistant cotton variety.

TOBACCO -- Black Shank: Tisdale (17) in Florida indicated that injury caused by the root nematode (Meloidogyne sp.) may affect the degree of resistance of tobacco to black shank (Phytophthora parasitica var. nicotianae). A report from North Carolina (11) stated that fumigation had little effect on black shank development on susceptible varieties; however, on resistant varieties, black shank development was delayed and was less severe. More recently, it has been demonstrated that root knot nematodes (Meloidogyne spp.) increased the expression of black shank on a resistant tobacco variety (13).

The present level of black shank resistance is not high enough to permit continuous crop-

ping of tobacco on severely infested land even when fumigation is combined with the use of a resistant variety.

TOMATO -- Fusarium Wilt: Based on field observations, Young (19) in Texas suggested that a root knot nematode increased the severity of wilt (F. oxysporum f. lycopersici) on tomato. Also (6), there was less wilt on the Marglobe tomato following a resistant crop of peanut (33.5 percent) than following root knot susceptible cowpeas (85 to 95 percent). Using carbon disulfide as a soil fumigant, Young (20) controlled root knot nematode but did not control the wilt.

In greenhouse tests in Beltsville, McClellan and Christie (9) were unable to demonstrate any influence of root knot nematodes on the incidence of tomato wilt.

OTHER SOIL-BORNE FUNGUS DISEASES: A report from Georgia (5) states that D-D and ethylene dibromide treatments have consistently controlled southern stem rot and root rot (Sclerotium rolfsii) on tobacco. These fumigants have also given partial control of fusarium wilt (Fusarium oxysporium f. nicotianae).

Soil fumigation for sweetpotatoes controlled nematodes, wireworms, and black rot (10).

MEADOW NEMATODE AND ROOT ROT: Observations on roots of different plants that are attacked by nematodes reveal that the different crops vary greatly in their reactions. Roots of some plants break down rapidly following attack, while roots of other species remain apparently sound. Hastings and Bosher (7) studied the association of the fungus Cylindrocarpon radicicola and a meadow nematode. On some of the plant species they found that there was a greater reduction in plant growth when both organisms were used in combination than when either was used alone. The data are not clear as to how many plants or replications were used in the test.

DEFICIENCY DISEASES: Chitwood, et al., (4) reported that various nematodes were associated with the decline and chlorosis of peaches. Chlorosis appeared to be due to a deficiency of magnesium or iron or both. It is logical to suspect that the interference of nematodes may be a factor in some cases where woody plants are slow to respond to soil applications of the deficient elements.

In South Carolina in 1952, observations made on soybeans growing on sting nematode-infested fields revealed that 90 percent of the plants showed severe symptoms of iron deficiency. In a second field observed in 1953, soybeans grown on land infested with an undescribed nematode showed nitrogen deficiency symptoms. An examination of the roots revealed root rot accompanied with an apparent reduction of nodulation in deficient areas.

WHEAT -- Dilophospora Disease: Most of the attention has been focused on soil-borne diseases. The work of Atanasoff (2) showed that nematodes might also be a factor in leaf and stem diseases. Working with the fungus Dilophospora alopecuri, and with the wheat gall nematode, Anguina tritici, Atanasoff found that he was able to reproduce the Dilophospora disease when he inoculated plants infected with the nematode. Inoculations with the fungus alone failed to produce the disease. He also observed that further spread of the disease stopped when the plants with the nematode died out or formed galls.

Recently, Johnson and Leukel recorded the association of the fungus and the nematode on wheat from South Carolina.

A similar disease relationship has been suggested for the bacterium Corynebacterium tritici and the wheat gall nematode (18).

CONCLUSION: Dr. G. Steiner of the Section of Nematology, U.S. Department of Agriculture, has frequently pointed out that soil-borne diseases are, in some instances, of complex character, and that nematodes frequently are members of such complexes, acting as initiators, cooperators, synergists, aggravators, or otherwise (16). He has suggested that nematodes may be carriers of bacteria and fungi and may possibly play a role in some of our "soil-borne" virus diseases.

Interest in the role of nematodes in our complex soil problems is on the increase. It is reasonable to expect that rapid progress will be made.

Selected References

1. Arndt, C. H. and J. R. Christie. 1937. The comparative role of certain nematodes and fungi in the etiology of damping off, or soreshin, of cotton. Phytopath. 27: 569-572.
2. Atanasoff, D. 1925. The Dilophospora disease of cereals. Phytopath. 15: 11-40.
3. Atkinson, G. F. 1892. Some diseases of cotton. Alabama Agr. Exp. Sta. Bul. 41.
4. Chitwood, B. G., A. W. Specht, and Leon Havis. 1952. Root knot nematodes. III. Effects of Meloidogyne incognita and M. javanica on some peach root stocks. Plant and Soil 4: 77-95.
5. Fungicide Committee of the American Phytopathological Society. 1949. Nation-wide results with fungicides in 1948. Fourth annual report. Plant Dis. Reptr. Suppl. 181. p. 80.
6. Harrison, A. L., and P. A. Young. 1941. Effect of root-knot nematodes on tomato wilt. Phytopath. 31: 749-752.
7. Hastings, R. J., and J. E. Bosher. 1938. A study of the pathogenicity of the meadow nematode and associated fungus Cylindrocarpon radicicola Wr. Canadian Jour. Res. 16 (Sec. C): 225-229.
8. Holdeman, Q. L., and T. W. Graham. 1953. The sting nematode breaks resistance to cotton wilt. (Abs.) Phytopath. 43: 475.
9. McClellan, W. D., and J. R. Christie. 1949. Incidence of Fusarium infection as affected by root knot nematodes. Phytopath. 39: 568-571.
10. Meuli, L. J., and A. S. Swezey. 1949. Soil fumigation for the control of sweet potato black rot. Down to Earth 5 (3): 2-4.
11. Nusbaum, F. J., and J. F. Chaplin. 1952. Reduction in the incidence of black shank in resistant tobacco varieties by soil fumigation. (Abs.) Phytopath. 42: 15.
12. Oteifa, B. A. 1952. Potassium nutrition of the host in relation to infection by a root knot nematode. Helminth. Soc. Wash., Proceed. 19: 99-104.
13. Sasser, J. N., H. R. Powers, Jr., and G. B. Lucas. 1953. The effect of root knot nematodes (Meloidogyne spp.) on the expression of black shank resistance in tobacco. (Abs.). Phytopath. 43: 483.
14. Smith, A. L. 1948. Control of cotton wilt and nematodes with a soil fumigant. Phytopath. 38: 943-947.
15. __________, and J. B. Dick. 1952. The inheritance of resistance to fusarium wilt in upland and sea island cotton. (Abs.). Phytopath. 42: 287-288.
16. Steiner, G. 1953. Changes in basic concepts of plant nematology. Plant Dis. Reptr. 37: 203-205.
17. Tisdale, W. B. 1931. Development of strains of cigar wrapper tobacco resistant to blackshank (Phytophthora nicotianae Breda de Haan). Florida Agr. Exp. Sta. Bul. 226.
18. Vasudeva, R. S., and M. K. Hingonia. 1952. Bacterial disease of wheat caused by Corynebacterium tritici (Hutchinson) Bergey et al. Phytopath. 42: 291-293.
19. Young, P. A. 1939. Tomato wilt resistance and its decrease by Heterodera marioni. Phytopath. 29: 871-879.
20. __________. 1940. Soil fumigation with chloropicrin and carbon bisulphide to control tomato root knot and wilt. Phytopath. 30: 860-865.
21. Young, V. H. 1938. Control of cotton wilt and "rust" or potash hunger by the use of potash-containing fertilizers. Arkansas Agr. Exp. Sta. Bul. 358.

SOUTH CAROLINA AGRICULTURAL EXPERIMENT STATION, FLORENCE, SOUTH CAROLINA

RECENT DEVELOPMENTS WITH ECTOPARASITIC NEMATODES

T. W. Graham

Among the important new developments relating to ectoparasitic nematodes is the growing recognition of the damage these pests are able to do to our crops in the South. There is no real reason why we should separate the ectoparasitic nematodes from others insofar as damage to crops is concerned, since the final effect is much the same for all nematodes. The increased recognition of nematode diseases as a factor is evidenced by the widespread increase in the use of soil fumigation. For example, in South Carolina we estimate that approximately one-half the tobacco land in the State was fumigated last year, which represents about 60, 000 acres. Similar interest in soil fumigation has developed in all the other tobacco growing States in the Southeast as well as in other parts of the country.

Perhaps the most significant advance in connection with ectoparasitic nematodes is that we are learning how to recognize them and how to study their effects on plants. New techniques of study were necessary because these organisms do not penetrate roots but instead feed from the root surface and live in the soil. For this reason they are not usually found in examination of the roots, which would be the logical place to look for an organism causing a root disease. The Baermann funnel method of washing and screening soil samples is the basic step leading to better techniques in studying ectoparasitic nematodes and the diseases they cause.

Recently Dr. Christie in Florida has studied the effects of the sting nematode and the stubby root nematode, and has shown how serious these pests are on numerous vegetable crops in that area. Dr. Holdeman and myself in South Carolina have studied the sting nematode on cotton and other field crops on which its effects can be devastating. We found, also, that this nematode can live and increase on a large number of wild and cultivated plants. The same nematode has been found doing serious damage to peanuts in Virginia by Dr. Lawrence Miller. Recently we have had occasion to study the tobacco stunt nematode, *Tylenchorhynchus claytoni,* which is parasitic on tobacco. Another species, *T. dubius,* was recently reported by Dr. Reynolds in Arizona to be parasitic on cotton and beans. Dr. Martin and his associates are pointing out the nematode troubles in Louisiana. Mr. Machmer has indicated that the ring nematode is causing damage to peanuts in parts of Georgia, and we have observed this in South Carolina too, as well as ring nematode damage to tobacco.

This is by no means a complete account of active work on ectoparasitic nematodes but it does indicate the awakening interest in these important plant pests.

SOUTH CAROLINA AGRICULTURAL EXPERIMENT STATION, FLORENCE, SOUTH CAROLINA

VALUE OF GREENHOUSE TESTS IN EVALUATING THE HOST RANGE OF NEMATODES

Q. L. Holdeman

For many years, most agricultural workers in the Southeast have been considering only one nematode, the root knot nematode. Research work in recent years has shown that the root knot nematode is actually composed of a group of species. Also, other parasitic nematodes are now being recognized by agricultural workers. Greenhouse tests that have been reported in recent years have shown that these different species of nematodes have a larger host range than has been previously suspected. Also, crops loosely termed as "nematode resistant" are very susceptible to some of the nematode species or, at least, are capable of building up or perpetuating a population of a nematode that would be damaging to the next crop in the rotation.

Work with soil fumigants has shown that nematodes can be controlled successfully on some of our annual crops. However, on certain low-income crops, the added cost of the fumigant, plus the other hazards of crop production such as insects and droughts, does not allow a satisfactory margin of gain. At present, there is no chemical therapeutant that can be used to control nematodes on perennial crops. To cope with these conditions, the research worker will have to revise his approach to the problem. Host ranges of the nematodes involved will have to be studied. When the information is compiled, then the agricultural worker will be able to re-evaluate crops to be used in rotations and for orchard cover crops.

It must be realized that greenhouse tests are conducted under atypical conditions and that final conclusions cannot be drawn until actual field trials are conducted. However, greenhouse tests will give an indication of the reaction and troubles to be expected in the field.

Reports on greenhouse tests are already being published and it is expected that other research workers will become interested in such work; therefore, it seems advisable to point out some of the problems involved. Some of the factors that should be taken into consideration are discussed below.

1. Field Soil. Satisfactory information can be obtained with some naturally infested field soils if the tests are watched closely and if weed seedlings are removed promptly.

2. Influence of Parasites. The main object of such trials is to find crops that reduce the numbers of nematodes. If nematode parasites interfere with the test, no definite conclusions can be drawn until the test is repeated.

3. Influence of Temperatures. Warm temperatures are needed for maximum activity; therefore, during winter months, cold areas near the edge of the greenhouse should be avoided. Limited observations suggest that the action of certain fungus parasites of nematodes might be increased in cold soils.

4. Rate of Seeding and Type of Plant Material. In one test comparing heavy seeding versus a single plant, it was observed that the populations under the single plants reached a much higher level. In another test, rooted cuttings of sweetpotato produced a higher population than did non-rooted cuttings. The initial attack on the latter was sufficient to almost eliminate root development, thereby reducing the root area available for feeding.

5. Length of Time. The life span of some nematodes is not known. The test should last long enough to allow the nematode to increase but yet not long enough to cause the nematode to die out because of destruction of the food supply. In two tests lasting 65 and 100 days, respectively, there was very little difference in the average populations of the spiral nematode, *Helicotylenchus nannus*, under soybean and oat. Corn and sweetpotato yielded a higher population after 100 days, while the reverse was true for rye and barley.

6. Collection of Data. Free-living nematodes are easy to work with and may be removed from standarized samples by screening and the Baermann funnel technique. However, for nematodes with different habits, techniques may have to be modified.

7. Varieties. Named varieties that are readily available should be used, if possible. Variations in the reports of workers in separate localities might suggest race differences; also, further examination of preserved specimens kept by the respective workers might later reveal species differences.

In some cases, differences might be due to the variation in the plant material. By making single plant selections of *Lespedeza sericea*, lines may be obtained that are resistant, tolerant, or highly susceptible to one isolate of *Meloidogyne incognita* var. *acrita.*

Greenhouse tests should prove a valuable method for obtaining information prior to the initiation of field tests.

SOUTH CAROLINA AGRICULTURAL EXPERIMENT STATION, FLORENCE, SOUTH CAROLINA

PLANT ABNORMALITIES CAUSED BY PARASITIC NEMATODES

T. W. Graham

The most obvious and easily recognized plant abnormality caused by nematodes is stunted and unthrifty growth. This symptom no doubt is a common response to invasion by all plant parasitic nematodes; therefore, stunting is the obvious sign that leads to the detection of nematodes. The usual response to nematode attack is not early death, but rather a slow decline. For example, with perennial plants this decline may extend over a period of several years. With annuals, often by the end of the growing season few plants may have died or even have showed obvious evidence of trouble, yet the overall damage on an acreage basis is likely to be very great. This is a basic reason why the actual extent of the damage due to many of our nematode diseases is overlooked. On the other hand, there are instances where crop damage is spectacular. One of the best examples of this that I have seen is the effect of the sting nematode on cotton, where large areas of an infested field may be denuded with losses of 50 percent or more.

I think it best at this point to discuss the specific symptoms described for the various nematode diseases that have been studied. I will confine this discussion to the root symptoms, since the top symptoms are not usually distinctive in separating the kinds of nematodes involved.

The Meadow Nematode, as you know, is an endoparasitic species which enters the root while feeding and spends at least a part of its life cycle in the root tissues. It is known to lay its eggs in the roots of tobacco and corn and perhaps in other plants that it feeds on. The early symptom on tobacco is a well marked lesion on the smallest roots. These lesions are reddish-brown in color and show up in marked contrast to the white healthy roots. Later there is a generalized root decay. On corn roots this nematode produces a very different effect, i. e., the invaded roots show a water soaked area instead of a well defined lesion. These two hosts also differ a great deal in the amount of root decay following attack by the meadow nematode. Tobacco roots decay very quickly even when relatively few nematodes are present, whereas corn roots may harbor large populations yet show relatively little root decay. This difference in symptoms caused by the same nematode on different plants is cited to show the significant fact that plants may vary greatly in their response to nematode attack.

The Stubby Root Nematode has been described by Dr. Christie as causing abnormalities in root growth by injury to the root tips. Root necrosis is not extensive, at least in the early stages, although this depends to some extent on the plant attacked. In most cases the root tips turn brown, but in some plants, e. g. corn, the browning is not extensive. In later stages a considerable amount of necrosis is evident, with many roots wholly or partially killed, but this condition is probably due to secondary invading organisms. Dr. Christie describes the stubby root disease as especially damaging to the seedlings. When the seed is germinating the growing point may be attacked and killed while very short. Effects on older plants may vary considerably. If roots reach a moderate length before growth is stopped a short stubby root system may result, with sometimes slightly swollen branches giving an overall stubby root appearance.

The Spiral and Sting Nematodes. We have had occasion to study the effects of the sting nematode on cotton, soybeans, and a few other crops in some detail, also the effects of the spiral nematodes on tobacco and tomatoes. These, of course, are ectoparasitic nematodes which feed from the root surface. We have found that both the spiral and sting nematodes cause a well marked root lesion in the early stages of attack, very similar to that caused by the meadow nematode. The first evidence is a dark shrunken area at any point along the root axis or the root tip, the latter often being killed before longitudinal growth starts. With cotton or tobacco general root decay starts rather quickly and the entire root system may be destroyed before the end of the growing season. On corn affected by the sting nematode we have seen a proliferation of short roots above the point of nematode attack, which results in a so-called "witches broom." Expression of these symptoms, however, is variable, depending on the plants affected, the number of invading nematodes, and perhaps other factors.

The Tobacco Stunt Nematode, *Tylenchorhynchus claytoni*. Although this is another ectoparasitic species its effect on tobacco roots is entirely different from that of other root nematodes. We found that root lesions are absent and root decay does not occur; however, the roots are seriously retarded in their growth and do not elongate normally. Instead, they remain short and clumped together in a dense mass. On close examination attacked roots appear shrunken and lack the turgidity of healthy roots. In pathogenicity trials the green weight of infected roots was invariably less than that of comparable healthy roots.

SOUTH CAROLINA AGRICULTURAL EXPERIMENT STATION, FLORENCE, SOUTH CAROLINA

HYPERPLASTIC ABNORMALITIES OF ROOTS OF OATS AND OTHER CEREALS AND GRASSES SUSPECTED TO BE CAUSED BY NEMATODES

S. S. Ivanoff

This is a report on certain hyperplastic abnormalities affecting the roots of oats, barley, wheat, and some other grasses noticed in Mississippi in the spring of 1953. Some greenhouse observations are also included.

The first abnormal oat specimens were found on the grounds of the Coastal Plains Branch Experiment Station, Newton, Mississippi, adjoining a small planting of Irish potatoes which showed what appeared to be a severe case of root-knot injury. The roots of the oat plants showed slight swellings resembling root-knot nematode injury on other plants, stubby terminals with tufts of secondary roots, some of them decaying, and general stunting of the entire root system (Fig. 1). On pulling up the oat plants, the individual roots seemed encased in a fine soil envelopment. The soil type in this locality is Prentiss fine sandy loam. Further investigations on two occasions showed that oats of several commercial varieties showed these abnormal manfestations. Barley showed the abnormalities also, as well as wheat, but the latter to a lesser extent. All affected plants appeared unthrifty. Corn examined at the Station grounds at that time did not show these symptoms. Unidentified grasses showed similar abnormalities to some extent.

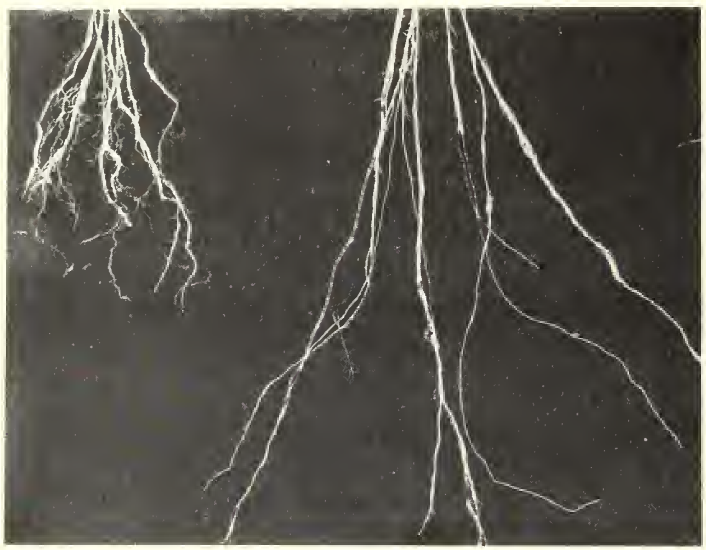

FIGURE 1. Left -- Stunted oat roots with swellings, suspected to be caused by nematodes.
Right -- Normal looking roots from an oat plant not showing such swellings. This plant was grown at a different location.

The general appearance of the affected roots suggested nematode injury. However, microscopic examinations did not reveal the presence of nematodes within the root tissue. Specimens of these oats were sent to Mr. A. L. Taylor, Nematologist, U. S. Department of Agriculture at Beltsville, Maryland, for a more thorough examination. Mr. Taylor stated that he found a large number of nematodes of the species *Panagrolaimus rigidus* around the roots and in the crowns. In the soil around the roots he also found species of the genus *Dorylaimus*. He did not find nematodes within the root tissue.

Cantaloupes and cucumbers were then planted in the same soil and locality where the abnormal oats were found. The cucurbit plants eventually developed typical root-knot (*Meloidogyne* sp.) symptoms.

Prior to the field observations, some greenhouse studies were made of injury to young oat

plants grown in nematode-infested soil. This light sandy loam was originally obtained from the vicinity of Columbus, Mississippi, and was used to grow cantaloupes. The cantaloupe plants showed slight to severe root-knot symptoms. Grass plants growing between the rows as weeds also showed slight swellings on the roots. Seeds of commercial oats were planted after the removal of diseased cantaloupe plants. After several weeks some of the young oat plants developed slight but distinct root-knot-like symptoms, including swellings on the roots, stubbiness of the roots, and tufts of secondary roots arising from stubby root terminals. Some of these root tufts showed signs of discoloration and decay. No nematodes were found inside the root tissues.

Following these observations the question may be asked: What caused the root abnormalities on the oats and on the other grasses? Two possibilities come to mind: 1) that the symptoms may have been induced by the activities of certain inadequately known ectoparasitic nematodes, or 2) that these abnormalities might have been caused by the mass action of one of the better known root-knot nematodes, the larvae penetrating the roots perhaps, but not multiplying or even surviving for any length of time within the root tissues.

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PARASITIC RACES OF MELOIDOGYNE INCOGNITA AND M. INCOGNITA VAR. ACRITA

W. J. Martin

In 1944 Christie and Albin (1) published their results showing the existence of races of the root-knot nematode, then known as Heterodera marioni. In 1949 Chitwood revised the classification of root-knot nematodes, placing them in the genus Meloidogyne and describing different species (2). Some of Christie's parasitically-different populations fitted into some of the newer species concepts.

Christie and Albin reported that certain of their populations failed to develop on cotton, variety Coker 100. Two of these populations that did not affect cotton were later placed in the species M. halpa (2).

Recently, Martin reported that certain Louisiana isolates of Meloidogyne incognita and M. incognita var. acrita failed to develop on the Deltapine 15 variety of cotton, while other isolates of this species and its variety infested and reproduced readily on Deltapine 15 (3). A summary of this data is given in Table 1.

Table 1. A summary of the development on Deltapine 15 cotton of different isolates of Meloidogyne incognita and M. incognita var. acrita from Louisiana.

Isolate	Species[a]	Development[b] on cotton
From tomato		
3H	M. incognita	-
3J	" "	-
3M	" "	-
3K	M. incognita var. acrita	-
3P	" " " "	-
3C	M. incognita	+
3L	" "	+
From okra		
15B	M. incognita var. acrita	-
15I	M. incognita	-
15D	" "	+
15F	" "	+
15L	" "	+
15J	M. incognita var. acrita	+
From Hairy Vetch		
28B	M. incognita	-
28E	" "	-
28C	M. incognita var. acrita	+
28D	" " " "	+
From Cucumber		
4A	M. incognita var. acrita	-
4D	" " " "	+
From Lamium amplexicaule		
31A	M. incognita var. acrita	+
31C	M. incognita	-

[a] Most of the identifications were kindly made by A. L. Taylor, Agriculture Research Service, Beltsville, Maryland. In some cases identifications were made by the writer, by determining whether the isolate did or did not infest Lycopersicon peruvianum.

[b] A plus (+) indicates development of mature females on the roots; a minus (-) indicates that mature females were not observed.

Table 2. Mean[a] rating for root galls on seven varieties of cotton with isolates of _Meloidogyne incognita_ (3 C 4-2 and 3L) and _M. incognita_ var. _acrita_ (19I and 19S).

Variety[b]	Isolate and mean rating for root galls				LSD
	3C4-2	3L	19I	19S	1%
Deltapine 15	4.00	4.00	4.00	3.00	-
A.H.A. 6-1-4	4.00	3.75	4.00	2.50	0.87
Coker 4 in 1 (Strain 5)	2.75	2.75	3.00	1.75	-
Clevewilt #3	2.25	1.25	2.25	1.50	-
Greer Wichita	3.75	3.25	4.00	3.00	-
Delfos 425	3.50	3.25	-	2.25	-
Deridder Red Leaf	4.00	3.25	4.00	2.75	-
LSD 1%	1.23	1.43	0.72	1.14	

[a] Mean of ratings made on four replicates.

[b] Varieties furnished by the Department of Agronomy of the Louisiana Agricultural Experiment Station.

Table 3. Mean number[a] of egg masses developed per plant on seven varieties of cotton by four isolates of root-knot nematodes.

Variety	Isolate and number of egg masses				LSD
	3C4-2	3L	19I	19S	5%
Deltapine 15	77.0	90.5	91.8	39.3	36.40
A.H.A. 6-1-4	44.8	98.3	91.3	14.8	-
Coker 4 in 1 (Strain 5)	35.3	49.8	51.5	10.0	-
Clevewilt #3	10.0	6.8	56.3	2.0	-
Greer Wichita	84.8	130.8	74.0	24.3	-
Delfos 425	63.8	45.3	-	15.5	29.83
DeRidder Red Leaf	75.0	56.8	92.5	19.0	-
LSD 5%	47.46	72.26	-	20.62	-

[a] Mean number on roots of one plant in each of 4 replicates.

To further study the comparative parasitism of certain isolates that infested Deltapine 15 cotton, four isolates of the nematodes were placed on seven varieties of cotton in carefully controlled inoculations in 6-inch clay pots containing sterilized soil. Inoculations were made in the following manner: 50 egg masses of each isolate from tomato roots were placed in 300 cc. of water and mixed in the Waring Blendor for 30 seconds. Ten cc. of this inoculum was poured over the seed in the appropriate pot before covering the seed with soil. Four replicates of each isolate on each variety were set up in sterilized sandy loam soil. The seed were planted on April 6, 1953 and notes were recorded on June 4-5, 1953.

Strikingly uniform root knot developed on the plants in any given pot. For that reason, all of the plants in each pot were given one rating, from 0 to 4 depending upon the severity of gall development, 0 being used for no evidence of gall formation and 4 for severe gall formation. The mean rating for root galls is given in Table 2. There were significant differences between isolates on variety A.H.A. 6-1-4. Isolate 19S was different from the other three isolates. Differences between varieties of cotton were indicated with all four isolates.

Data on the number of egg masses on one plant in each pot were taken and these data are given in Table 3. Significant differences between isolates are shown on two varieties, Deltapine 15 and Delfos 425. On both these varieties the isolate 19S produced fewer egg masses than other isolates. Differences between varieties were shown with three of the four isolates, but not with 19I.

Thus, the above results show that differences in parasitism on cotton among isolates of *M. incognita* and *M. incognita* var. *acrita* range from no parasitism in the case of some isolates, all the way to severe parasitism in the case of other isolates.

Literature cited

1. Chitwood, B. G. 1949. Root-knot nematodes - Part I. A revision of the genus *Meloidogyne* Goeldi, 1887. Proc. Helm. Soc. Wash. 16: 90-104.
2. Christie, J. R., and Florence Albin. 1944. Host-parasite relationship of the root-knot nematode, *Heterodera marioni*. I. The question of races. Proc. Helm. Soc. Wash. 11: 31-37.
3. Martin, W. J. 1953. Reaction of the Deltapine 15 variety of cotton to different isolates of *Meloidogyne*. (Abstr.) Phytopath. 43: 292.

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PROBLEMS IN BREEDING FOR RESISTANCE TO NEMATODES IN TOBACCO

T. W. Graham

Breeding work to develop disease resistant tobaccos is now actively engaged in by perhaps 12 people in the Federal and State agricultural research groups. About half of this group is interested in root-knot-resistant tobacco, which has been one of the most difficult tasks in breeding work with tobacco diseases.

Good sources of root-knot resistance from tobacco introductions and from species of *Nicotiana* have been used but, as yet, a high level of root-knot resistance has not been sufficiently stabilized in commercial tobaccos. There appears to be a very closely bound linkage between the factors controlling root-knot resistance and certain undesirable qualities in tobacco. Numerous lines in our breeding work have been selected with medium to high levels of resistance, but these lines almost always have been acquired by sacrificing some essential flue-cured qualities. While it would seem desirable to compromise with a medium level of resistance and a somewhat altered quality of tobacco, even this combination has not been satisfactorily stabilized. The pattern of inheritance for root-knot resistance has not been thoroughly investigated but it appears to be conditioned by multiple factors. Our experience indicates that numerous environmental factors as well influence the development of root-knot.

One of the practical difficulties in this work in the South Carolina area is the problem of keeping field plots uniformly enough infested to make critical selections. To overcome this, we are using greenhouse plantings in which we can keep soil infestation uniformly high. This procedure limits the number of plants that can be handled, but it has been a great help in making more critical selections. By using this system we now have advanced lines that show more promise of stabilized resistance.

SOUTH CAROLINA AGRICULTURAL EXPERIMENT STATION, FLORENCE, SOUTH CAROLINA

PROBLEMS ON BREEDING COTTON FOR RESISTANCE TO NEMATODES

Albert L. Smith

From the time of publication of Atkinson's (1) paper in 1892 until about 1938, the root-knot nematode was recognized as the only serious nematode problem with cotton. In the late thirties the meadow nematode, Pratylenchus pratensis, was found to be the predominant species affecting cotton in several locations. Pratylenchus was soon divided up into several species as new material was examined. Somewhat later the five species of Meloidogyne were described. This added to the confusion of the breeder and immediately the question of resistance to these new root-knot species became an important subject for investigation. Where cotton is concerned the investigation has not yet been completed. A few years later the ectoparasitic group of nematodes were found affecting cotton. Trichodorus and Belonolaimus appear to be the most serious of this type. There are of course a number of additional species affecting cotton which may or may not be serious problems for the future. However, it is apparent that new nematode problems on cotton are being found faster than old ones are being solved. Much work will necessarily have to be done before the distribution, relative abundance, symptoms produced by different species, life histories, and many other factors are determined. The possibilities of breeding for resistance to the newer types can be determined only after some of the many preliminary problems have been studied.

The problem of breeding for nematode resistance cannot be considered without giving attention to the nematode-Fusarium wilt complex on cotton. Atkinson (1) first recognized this relationship in 1892 in the first published description of the two diseases. The complexity of the problem is such that it is still not fully understood. However, two facts concerning the wilt-nematode relationship appear established which give a partial understanding of the situation:

1) -- The wilt pathogen (Fusarium oxysporum f. vasinfectum) is dependent on nematodes for entrance to the vascular system of the cotton plant. Apparently any one of several species can and do provide this means of entrance for the wilt pathogen.

2) -- The effect of nematodes on host susceptibility to wilt is a continuing one in later stages of plant development. This results in increased wilt susceptibility with increased nematode effect. Such a relationship can be demonstrated by the significant positive correlation obtained between root-knot susceptibility and wilt susceptibility, wilt susceptibility being the dependent variable.

With this understanding of the problem it is apparent that nematodes play the dominant role in the wilt-nematode complex, by first making an opening for the wilt organism and then by increasing the susceptibility of the host. From the disease loss standpoint the loss from Fusarium wilt may now be assigned indirectly to nematodes. When this loss from wilt is combined with the direct loss in yield from nematode effect then nematodes may be considered as the major cotton disease problem of the lighter soils of the rainbelt and of the lighter soils of the irrigated regions.

The root-knot nematode is still considered the major pest of cotton although other species may locally become predominant and cause greater losses. Consequently the greatest immediate benefit from a breeding program for nematode resistance appears to be in the improvement of root-knot resistance. The present level of root-knot resistance in commercial cottons is shown in Table 1. In this table the varieties are grouped on a basis of parental origin. The Clevewilt group, consisting of Coker 100 Wilt, Stonewilt, and Plains, in addition to Empire, are the major varieties planted on nematode- and wilt-infested soils. The newly released Auburn 56 variety derived from Cook 307 is far superior in both root-knot resistance and the correlated Fusarium resistance. Studies at Tallassee, Alabama, show the Clevewilt group of varieties could be improved in yield 25 percent by using Auburn 56 resistance and Empire could be improved in yield 35 percent in the same manner. As a practical approach to the problem it is suggested that Auburn 56 resistance might be utilized in initiating new crosses to improve established varieties.

The overall root-knot resistance of the most resistant variety of upland cotton is actually only 30 percent of total resistance, or absence of root-knot galls, as determined by the root-knot index method. Actually this resistance might be classed as only a moderate degree of tolerance. A rather wide search has been made through the species, subspecies, and numerous varieties of cotton for a better source of root-knot resistance. Thus far the most prom-

Table 1. Percentage of wilt, reaction to root-knot, and yield on untreated and row-fumigated soil, of 23 commercial cotton varieties. Varieties are grouped according to parental source of nematode and Fusarium resistance. Tallassee, Alabama. 1953.

Source of resistance[a]	Wilt percent	Root knot index	Acre yield lint untreated	Acre yield lint treated	Increase from treatment Pounds	Increase from treatment Percent
Cook 307	9.6	73.4	671	790	119	17.7
Cook 144	29.1	79.9	568	741	173	30.5
Clevewilt	31.7	87.2	542	735	193	35.6
Empire	38.7	89.4	500	777	278	55.6
Fusarium susceptible	78.6	97.3	235	564	329	140.0

[a] Varieties included in the above groups are as follows:
Cook 307: Auburn 56-7, 24 and 33.
Cook 144: Smith 78, Smith 78-25, and H81.
Clevewilt: Coker 100 Wilt, Plains, and Stonewilt.
Empire: Empire, All in One Cross, and Bobshaw-Hybrid.
Fusarium susceptible: Deltapine 15, Stoneville 2B, and Miller 610.

[b] Soil row-treated with 2 gallons of Dowfume W85 per acre.

ising material found is a wild cotton, Gossypium barbadense var. darwinii. This cotton, although short-day sensitive and hard seeded, crosses readily with upland. The evidence obtained in early crosses suggests that root-knot resistance is inherited recessively and may be polygenic. Thus it is obvious that many generations and much time will be involved in transferring such resistance to upland. However, a considerable improvement in yield on nematode-infested soils would be expected from the improved root-knot resistance. An estimated 30 to 40 percent improvement in yield is considered possible with the Clevewilt group of varieties, should maximum resistance be achieved. The differences in yield between the varietal groups on treated and untreated soil in Table 1 indicate the amount of improvement possible to attain. Observations indicate that some improvement in resistance to other nematode species would occur with improved root-knot resistance.

Literature Cited

1. Atkinson, George F. 1892. Some Diseases of Cotton. Alabama Agr. Expt. Sta. Bul. 41.

ALABAMA AGRICULTURAL EXPERIMENT STATION AND FIELDS CROPS RESEARCH BRANCH, U. S. DEPARTMENT OF AGRICULTURE

BREEDING SWEETPOTATOES FOR RESISTANCE TO THE ROOT-KNOT NEMATODE

H. B. Cordner, F. Ben Struble, and Lou Morrison

The common root-knot nematode (*Meloidogyne incognita* (Kofoid & White) Chitwood) is one of the most serious problems in growing sweetpotatoes. When this crop is grown in infested soil, some reduction in yield is inevitable; the roots may be largely unfit for market and are entirely useless as seed. The infected plants which result when diseased seed stock is used to propagate the sweetpotato crop are most effective in introducing root knot into cultivated fields.

At a relatively early date, root-knot injury to sweetpotatoes was observed and varietal differences reported (5, 4). In these studies, the varietal differences described were based on injury to plants in infested plant beds and plant and root injury in crops grown in infested field plots. In a more recent report (3), varietal resistance to root knot was based on the prevalence of egg masses on roots of plants grown for a short period of time in infested soil in greenhouse benches. In this report, it was indicated that the Jersey varieties were the most consistently resistant, the Porto Rico variety and its mutant strains were of intermediate resistance, while the Nancy Hall and Red Bermuda were highly susceptible to root knot. Breeding line and Plant Introduction sweetpotatoes were also tested and each assigned to one of the three resistance classes.

Work at the Oklahoma Experiment Station

In a study reported in 1953 (2), it was found that resistance to root knot in sweetpotato (and also tomato) relates to the rather extensive necrosis of root tissues which occurs when the nematode larvae are present in the roots. The larvae appeared to enter the root tips of susceptible and resistant sweetpotato varieties in equal numbers, but few nematodes developed to egg-laying maturity in roots of the resistant varieties.

The reaction of a number of breeding lines and sweetpotato varieties to root knot was reported in 1951 (1). In these studies (and those to be reported at this time) the plants of the test varieties and seedling lines were grown and observed in special field areas which show uniform distribution of the root-knot nematode. The classification of the varieties with reference to nematode resistance is based on the injury to the underground portion of the plant at harvest time (hill index) and the number of nematodes found in the storage roots. This preliminary study indicated that the Jersey variety, Orlis and other parent lines, might be used effectively in breeding for root-knot resistance.

As the breeding program has continued at the Oklahoma Station, the sweetpotato varieties and breeding lines serving as parents have been carefully tested and classified according to the degree of root-knot resistance. Similarly, large seedling populations were tested as F_1 individuals. In three years about 1400 of these F_1's were tested as first year plants (direct from seed) and many others as seedling clons. The results of these tests indicate that root-knot resistance is of high frequency in seedling populations from selected parents.

When a resistant parent is crossed with a resistant parent about 50 percent of the offsprings are resistant to root knot, about 30 percent are of intermediate resistance, and about 20 percent are susceptible. The individuals from the R x S parentage are about equally distributed in the resistant, intermediate, and susceptible classes. When two susceptible parents are crossed, the offspring show about a 10 percent, 25 percent, and 65 percent distribution in the R, I, and S Classes respectively.

The resistant parents referred to in this discussion are Orlis, Nemagold (Okla. 46), E 7, and eight Oklahoma breeding line sweetpotatoes. The resistance tests with named sweetpotato varieties confirm previous reports which indicated that the Jersey varieties are resistant, the Porto Rico types intermediate in resistance, and the Nancy Hall types are susceptible. In addition, this study has shown that Heartogold, Nemagold, and breeding lines B 5999, B 5941 (USDA), and E 7 (South Carolina) are resistant. Susceptible varieties are Allgold, Redgold, Earlyport, Vates Golden, and Virginian. When the varieties in the Jersey group are considered, the mutant Maryland Golden appears to be susceptible, although its parent, Big Stem Jersey, is resistant. Similarly, Orange Little Stem appears to be less resistant than the original Yellow Jersey or the related mutant varieties Orlis and Rols.

Literature Cited

1. Cordner, H. B., F. Ben Struble, and Lou Morrison. 1951. Reaction of sweetpotato varieties and seedlings to root knot nematode. 1951 Proc. Assoc. Southern Workers. P. 119.
2. Dean, Jack L., and F. Ben Struble. 1953. Resistance and susceptibility to root knot nematode in tomato and sweet potato. Phytopath. 43: 290.
3. Kushman, L. J., and J. H. Machmer. 1947. The relative susceptibility of 41 sweet potato varieties, introductions and seedlings to the root knot nematode, *Heterodera marioni* (Cornu) Goodey. Proc. Helminth Soc. Wash. 14: 21-23.
4. Poole, R. F., and R. Schmidt. 1929. The nematode diseases of sweet potatoes. North Carolina Agr. Exp. Sta. Bul. 265.
5. Weimer, J. L., and L. L. Harter. 1925. Varietal resistance of sweet potatoes to nematodes, *Heterodera radicicola* (Greef) Muller, in California. Phytopath. 15: 423-426.

OKLAHOMA AGRICULTURAL EXPERIMENT STATION, STILLWATER

FUMIGATION: THEORY AND PRACTICE

Albert L. Smith

The question concerning the recommending of soil fumigants to cotton growers in Alabama has been debated since 1947, when the effectiveness of these materials for controlling wilt and nematodes and for improving yields was first determined. The questions involved were economics and the extent of the need for nematode and wilt control. At that time the yields were much more erratic due to the boll weevil situation. The development and use of the newer insecticides has stabilized yields in proportion to the ability of the growers to learn how to apply them properly. Although the average yield of the Alabama cotton crop is still less than 300 pounds of lint, many growers are confident of their ability to produce an average of a bale or more per acre. With production and price more stabilized it now appears more economically feasible to introduce soil fumigation as a cultural practice. In addition, the incentive to obtain higher yields on alloted acreage reduces grower resistance to experimening with a new and expensive operation. With the finding of many new species of nematodes attacking cotton and with losses apparently increasing and becoming obviously quite serious in localized instances the needs for fumigants are no longer questionable. Rather, fumigation is becoming a matter of necessity in some instances.

The question of equipment should be considered first. In view of the small size of farms in Alabama and the spotted nature of most wilt and nematode infestations there is need for inexpensive equipment to treat small areas. Fortunately the tobacco workers have pioneered in the development of equipment consisting of tanks with gravity flow apparatus. This equipment appears more practical for the majority of growers than the more expensive pressure system. Gravity tanks used in combination with the narrow feet developed for application of liquid ammonia and fitted on a one or two-row tractor should prove satisfactory. Difficulty has been experienced in using gravity flow to obtain the 2-gallon rate of application of Dowfume W 85. A more satisfactory flow of the liquids was obtained with Dowfume W 40 and DD applied at the 7- to 10-gallon rates per acre.

Annual row application appears necessary for cotton. Experiments indicate that the carry-over value of row application is negligible when the soil is disked or plowed and rows are remade. The rush season on a cotton farm comes just before planting, consequently the application of fumigant and fertilizer may be combined into one operation or the fertilizer may be applied at time of planting. Experiments indicate that some risk to the stand is involved by planting at the time of application of fumigants, although yields have not been lowered because of reduced stands at the rates recommended for cotton. It is believed, however, that the period of waiting after planting may be safely placed at five to seven days rather than the ten days to two weeks generally recommended for other crops.

Limited experience with field application of fumigants indicates many opportunities for failure to obtain satisfactory results. Some of these involve poor methods, such as too shallow placement, failure to firm the soil properly and promptly, and application when the soil is too moist or too dry. Planting on a loose seedbed caused by deep application with later settling of the soil and burying of the seed too deep is another hazard. Seasonal effects on the crop or nematode population, or both, may give completely negative yield results from treatment. It is anticipated that growers will rapidly learn, with a few years experience, the factors involved in application of fumigants to obtain satisfactory results.

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SOME PRACTICAL ASPECTS OF SOIL FUMIGATION

C. W. McBeth

The use of soil fumigants for control of plant parasitic nematodes and other pests has grown at a prodigious rate during the past eight to ten years. Due to the high cost and difficulties associated with the use of available materials, soil fumigation was confined to greenhouse and nursery before the discovery of D-D[1] (dichloropropene-dichloropropane) and EDB (ethyl dibromide). In Hawaii no pineapple is planted without first fumigating the soil. In the United States, the major portion of soil fumigants are being used as preplant treatments for tobacco, cotton, and vegetables. In some areas, large amounts of fumigants are being used as preplant treatment for perennial crops such as citrus, peach, almond, walnut, and grape. To date, there is no chemical on the market that can be recommended for treating living plants for control of nematodes. Both D-D and EDB have been used experimentally, but the margin of safety is quite narrow for either material.

Desirable Qualities of a Nematocide

Certain workers have stated that the ideal soil fumigant should be toxic to nematodes, fungi, weeds and weed seeds, but not harmful to living plants. This of course is not possible because if a material is toxic to weeds it is probably also toxic to other plants. The ideal fumigant then would be one that is toxic to nematodes and fungi, but not toxic to plants. Even this, at present, seems to be too broad, as in general, most chemicals that are highly toxic to fungi are also toxic to plants. Therefore, rather than looking for a universal fumigant, it will probably be more profitable to look for a material that will do one thing well. The ideal nematocide as we define it, would be one that is highly toxic to nematodes and relatively non-toxic to plants. Even this appears to be a rather tough problem but is probably more nearly possible than the finding of a non-phytotoxic combination nematocide-fungicide.

To be an effective nematocide, a chemical must not only be toxic to nematodes but it must be capable of dispersing itself thoroughly in the soil. Nematodes are very small worms and do not move readily through the soil. In fact some forms, such as cyst nematodes, are primarily in a totally immobile stage at the time fumigation is ordinarily done. Plant parasitic nematodes are distributed throughout the soil from the surface to several feet deep depending on the root systems of the crops that have been grown. Root knot nematodes have been found down to 3 feet on alfalfa and 5 to 6 feet on peach roots.

With our present methods of application, a soil fumigant should be volatile, with sufficient vapor pressure to spread laterally 6 to 8 inches through the soil from the point of injection. Even though a non-volatile material is highly effective, it is almost impossible to mix it thoroughly with the soil to more than 6 to 8 inches in depth. 1, 4-dibromobutene is a good example of this type of material. Thorough mixing with the soil of 75 to 100 pounds per acre will control nematodes down to 1 foot depth, but it is not practical to attempt a thorough mix to that depth on a field scale.

A residual material would be highly desirable providing it is non-phytotoxic, although it would probably have the disadvantage of having to be mixed with the soil because a volatile material would probably not stay in the soil for long periods. Even with D-D and EDB, which have very little residual nematocidal value, damage sometimes results to crops planted too soon after treatment.

Mode of Dispersion of Fumigants

Although the manner in which volatile chemicals disperse through the soil is not thoroughly understood, the movement is almost certain to be in the vapor phase following the laws of diffusion. The rate of diffusion is determined by the vapor pressure of the chemical.

Chitwood[2] states that soil fumigants tend to saturate the soil moisture in their vicinity before moving further. This would indicate that the vapor moves in the water phase and, therefore, fumigants highly soluble in water would not move far in the soil without using excessively

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1 Trademark Registered

2 Chitwood, B. G. Nematocidal action of halogenated hydrocarbons. Paper given at meeting of American Chemical Society, September 3-8, 1950, Chicago, Illinois.

high dosages. D-D, which is soluble to .1% (1000 ppm), moves quite readily in soil except where excessively high moisture is present. This, we believe, is due to reduction of porosity rather than its water solubility.

Factors Affecting the Activity of Soil Fumigants

There are at least five important factors which affect the activity of soil fumigants. These factors are discussed under the respective headings although not necessarily in the order of importance.

1. Soil Temperature -- The ideal temperature for application of any one fumigant is dependent upon the boiling point and vapor pressure. In general, the higher the temperature, within limits, the more effective the fumigant. Of course, if the temperature is too high, the vapor escapes from the soil too soon to effect a kill or to give a thorough fumigation. In general, our experience has shown that chemicals with a boiling point of 150° to 200°C are most effective at a temperature of 80°F (27° C) or higher. In controlled temperature tests these materials have been almost non-effective at soil temperatures of 50° F or less. The time required for D-D with boiling point of 130° C to diffuse 6 inches in a sandy soil is less than 24 hours at 75° F and 96 hours at 45° F. At low temperatures, high boiling point materials volatilize so slowly that a lethal dosage is not built up, or the chemical breaks down before it has had time to diffuse thoroughly.

2. Soil Moisture -- Soil moisture can be very critical in the dispersion of soil fumigants. In our work, we have found that some moisture is desirable but that it should be less than field capacity. Our experience has shown that with sandy, sandy loam, or clay loam soils, the moisture should not be more than 85 percent of moisture equivalent (field capacity) or less than 50 percent of moisture equivalent. Apparently, a higher percentage of moisture reduces the pore space in the soil and interferes with dispersion. Too dry soil allows the fumigant to escape without complete diffusion, or, according to unpublished work of Crafts and our own limited work, the material is highly sorbed when the soil is quite dry.

3. Soil Type -- Soil type is a very important factor in diffusion of soil fumigants. Experience has shown that heavy clay soils are not suitable for fumigation with the fumigants now available. The reason for this is probably due to sorption, either because of increased active surface area of the soil particles, or the blocking of pore spaces by soil moisture. At our laboratory we measure the suitability of a soil for fumigation by the moisture equivalent. We have found that where soils have a moisture equivalent of 25 percent or more, the dosage must be increased to be effective. In our experimental work, we determine moisture equivalent of all prospective plot sites before applications are made. In general, we avoid soils approaching a moisture equivalent of 30 percent. The volcanic soils of Hawaii have a M.E. of 32 percent and the best results are secured at the rate of 80 gallons of D-D per acre, which is three to four times the dosage required for soils of M.E. of 20 percent or less which are most desirable for fumigation.

4. Compaction -- For best results, soil to be fumigated should be well worked as deep as practicable. Sub-soiling with chisels 10 to 12 inches apart or deep plowing is desirable. The soil should be pulverized as much as possible as fumigants will not penetrate clods, especially if on or near the soil surface. The soil preparation should be as near seed bed condition as possible. As stated in Hansen's[3] paper, the porosity of soil is greatly reduced by compaction and the reduced porosity in turn reduces the dispersion of the chemical.

5. Sorption -- Very little is known concerning sorption of chemicals by soils. Work at our laboratory and by Crafts and others has shown that chemicals are sorbed to a greater degree by dry soil than moist; although Hansen[3] says that EDB is sorbed least at wilting point and to a greater extent as the moisture content is increased or decreased. This is possibly due to two different types of sorption. In dry soil the material would be held by soil particles and perhaps in the wet soil the chemical would be taken up in the water, depending on solubility. The effect of sorption on dispersion of soil fumigants is not well understood. In theory, a certain degree of sorption is probably desirable although a high degree would reduce dispersion and increase phytotoxicity. Peat soils, which are high in organic matter, are not favorable for fumigation due to a high degree of sorption. This difficulty has been somewhat overcome in muck soils of Indiana and Michigan by closer spacing of chisels and increased dosage rates.

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[3] Hansen, W. J. and R. W. Nex. 1953. Diffusion of ethylene dibromide in soils. Soil Science 76 (3). Sept.

New Materials

There are several experimental new materials being tested at present. Although the chemical nature of some of these materials has not been divulged, the activity is fairly well known. As far as we are aware, none of these materials is proven to be more effective than D-D or EDB with the exception of an experimental Shell product known as OS 1897. This material is approximately ten times more effective than D-D and is comparatively non-toxic to living plants. The mode of action on nematodes is not known but is believed to be different than for other materials now in use. Evidently, this material is a very slow nematode poison and is residual in the soil for several weeks. This material is the most effective material tested by our laboratory. The main difficulty is that seed germination has been depressed in some instances by this material. It has been used both by injection and emulsion on living plants, without damage, at well over nematocidal dosages.

Preliminary field results have shown this material to be quite effective on cyst nematodes at 2.5 to 5 gallons per acre.

In row application for cotton and tomatoes, very satisfactory root knot nematode control has resulted with as low as 0.5 to 1 gallon per acre.

Practical Application of Soil Fumigants

Commercially, soil fumigants are applied as liquids either by chisel injection or by dripping or spraying in front of mold board plows. In both methods, the metering is usually done by a pressurized manifold with an orifice in each line. This method requires a pump, CO_2 tank, or some other method of forcing the chemical through the orifices. Where only one or two lines or outlets are used, a gravity flow method has been developed by the Insect Control Service of Charlotte, North Carolina. The metering is accomplished by a regulating valve in each line. This valve can be opened or closed for desired dosage.

At our Modesto Laboratory it was necessary to develop equipment for applying chemicals at very low dosages, 1 gallon or less per acre on 12 inch spacing. To do this, a system was developed whereby the metering was accomplished by capillary tubing. This was at first accomplished by using short lengths of small bore glass tubing, but considerable trouble was experienced due to plugging of the small openings. Finally, the possibility of using lengths of Saran tubing in the same manner as a capillary tube was tried. It was found that this tubing could be used as an orifice providing a constant head vessel was used. The dosage was found to vary indirectly with the length of the tubing and directly with the effective head. This method of metering is very effective in that no plugging results even with very low dosages due to comparatively large openings in the tubing. The main difficulty is that if more than one outlet or tube is used per vessel, a means of cutting off each line is necessary to insure proper functioning. This can be done either with multiple valves or a valve on each line.

Row and Solid Applications

For close planted crops, such as most vegetables, or where a high degree of control is necessary, a solid application is used. As described above, this is accomplished by pressurized manifold with chisels spaced 12 inches apart.

Row applications are made on wide planted crops such as tobacco, cotton, tomatoes, and melons. In some cases only the planting site or the row is treated for grapes and trees. For perennial plantings, the solid application is considered to be most desirable, however, because of the long period over which the plants are grown. In row application, the amount of fumigant used can be greatly reduced. For example, row applications for tobacco require less than that required for solid application. Raski and Allen[4] reported on control of root-knot nematode of cotton by row application of D-D. In this experiment, the application of from 4 to 12 gallons of D-D per acre increased the yield by 1/2 to 1 bale of lint cotton per acre over the untreated. The nematode control ranged from 25 percent control at 4 gallons per acre to 80 percent control at 12 gallons.

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[4] Raski, D. J., and Allen, M. W. 1953. Control of root knot nematode of cotton. Plant Dis. Reptr. 37 (4).

FACTORS AFFECTING RESULTS WITH SOIL FUMIGANTS

C. E. Dieter

Soil fumigation is the application of volatile chemicals to the soil for the control of undesirable soil-borne organisms that interfere with plant growth. These fumigants must therefore diffuse throughout the soil mass, and remain there at a toxic concentration for a sufficient period to give satisfactory control. They should leave no persistent residues that are toxic to the subsequent crop. To accomplish this they must be applied under the right conditions and by the correct method.

In practice, however, soil fumigants are often necessarily applied when needed and at the convenience of the operator. They are rarely applied in compliance with all of the recommended conditions. The results obtained may range from poor to good as reflected by pest control or plant growth, depending upon how near the actual conditions at time of application approached the recommended ideal.

FIGURE 1. Control of the nematode-Fusarium wilt complex of cotton with a soil fumigant applied in the row. Note good cotton on right and left while the two center rows are poor due to faulty application.

Chemicals for the control of soil-borne plant parasitic nematodes have come into extensive use in recent years, due largely to the development of ethylene dibromide and dichloropropene-dichloropropane mixture, which can be used economically for large scale field applications. These materials will control insects and nematodes, and indirectly certain soil-borne diseases. Chloropicrin and methyl bromide are used in small scale specialized operations for the control of insects, nematodes, weeds, and certain soil-borne diseases. There are still many nematode problems for which satisfactory control measures have not been developed, such as control of nematodes around living plants and in heavy soils. With a better understanding of the factors involved in fumigation more progress should be made in the future.

This report is an attempt to familiarize those interested in the control of nematodes and other soil-borne pests with the importance of some of the conditions and factors that may influence the results obtained from applications of soil fumigant materials. It is important that these conditions and certain other factors be noted and considered not only at the time of application but throughout the growing season in order to determine the value and limitations of a soil fumigant.

The literature dealing with the effect of soil conditions on the effectiveness of soil fumigants is difficult to summarize due to the diverse conditions under which the work has been conducted. The interaction of the various factors affecting soil conditions is important, but seldom considered. A review of the literature however indicates that investigators are in general agreement on the conditions essential for satisfactory fumigation. These conditions are as follows: 1) sandy soils can be treated more successfully than clays or highly organic types; 2) soil at time of application should be in good tilth; 3) plant roots of the previous crop should be decomposed and the trash should be well buried; 4) moisture should be moderate and uniform throughout the soil mass; 5) soil temperature does not appear critical when between 50° and 85°F, however, the higher temperatures in this range are more desirable, particularly for chloropicrin; 6) the immediate leveling and compacting of the soil surface is necessary to seal in the fumigant following treatment with dichloropropene-dichloropropane mixture and ethylene dibromide; 7) a gas-proof cover is necessary when using methyl bromide and a gas-proof cover or water seal is desirable when using chloropicrin. It is interesting to note that the conditions required for satisfactory results with soil fumigants are essentially the same as those necessary when using steam in buried tile lines for soil sterilization. These conditions are necessary to give an even distribution of the steam throughout the soil and they are even more critical for satisfactory results with chemicals for soil treatments. The fumigants must travel from the point of application throughout the soil mass by gaseous diffusion in the soil atmosphere. The chemicals apparently must be dissolved in the soil moisture around the pests in order to control them.

Field observations have shown that the sandy soils and lighter loams are more readily fumigated than other types. High soil moisture (10 to 15 percent on dry weight basis) and low porosity appear more necessary with ethylene dibromide than with dichloropropene-dichloropropane mixture. Clay soils can be satisfactorily treated if they are in a physical condition that will permit the satisfactory diffusion of the fumigant. High soil moisture (100 to 200 percent on a dry weight basis) is essential for satisfactory results with the highly organic soils, which have extremely high moisture equivalents. Moisture apparently functions in reducing porosity and satisfying the high sorptive capacity of these organic soils. Larger dosages of fumigants are required for consistent results on organic soils than on mineral soils.

Extremely dry soils apparently cannot be successfully treated due to the sorption and the too rapid escape of the fumigant. Conditioning of the pests by soil moisture may also be involved. Excessive soil moisture interferes with the diffusion of the fumigant, as indicated by poor root-knot nematode control in root crops such as carrots. When downward diffusion is apparently limited by the height of the soil water table the tips of carrots are severely galled while the upper portions are clean. Lateral diffusion is also inhibited. Wireworms, however, have been controlled in wet soils, possibly because they were in the upper soil layer. Even when methyl bromide is applied to a dry soil under a gas-proof cover poor results are obtained. A wet soil will prevent the penetration of the fumigant, and will also result in poor control and often plant injury.

The fumigant materials generally must be dissipated from the soil before satisfactory plant growth can be obtained. It appears that conditions essential for satisfactory treatment are not necessarily suitable for aeration. Soils should be fairly loose and dry for proper aeration. The fumigants, if not dissipated from the soil surface into the air, are mineralized and remain in the soil as various residual breakdown products. Under certain conditions they may be phytotoxic. Heavy rains following treatments often necessitate prolonging the aeration period before planting. When the fumigant is present in the upper soil surface reduced stands may result. When it is present at deeper levels plant toxicity symptoms may be delayed and sprangled roots may occur on root crops.

It appears that some so called failures of soil fumigants as measured by plant growth response are due to the fact that certain desirable organisms are temporarily reduced. For example, under certain conditions onion yields are reduced because of early maturity attributed to high ammonia nitrogen which upsets the nitrogen-carbohydrate ratio. This reduction may be in direct proportion to the inhibition of the nitrifying bacteria. It is indicated that ammonia injury can be corrected with applications of nitrate nitrogen or by increasing the available calcium in the soil. The stunting and chlorosis of pine seedlings which sometimes follows seedbed treatments with methyl bromide has been associated with the reduction of the mycorrhiza which are necessary for the normal growth of conifers.

It may not be desirable in many instances to completely disinfest the soil but only to temporarily reduce the pests in order to allow the plant to become well established. It is often difficult to correlate certain crop yield increases following fumigation with the high nematode

populations present at the end of a growing season as compared to the low yields and the low populations present in untreated areas.

When soil fumigation results are measured by plant growth or crop yields and not by actual pest control, plant tolerance to the fumigant cannot and should not be ignored. Yields might be more a measure of phytotoxicity than of pest control. This is an especially important point to be considered when only a single dosage is used in a soil fumigation experiment, since the effects of other dosages are not available for comparison.

It has been found necessary to correct plant nutrient deficiencies or imbalances and soil reaction for a particular crop before satisfactory results can be obtained from soil fumigant applications. In some instances it also may be necessary to change the fertilizer recommendations for certain crops when the soil is fumigated. It has been found that the ammonia nitrogen balance is important for crops such as potatoes and tomatoes following fumigation with ethylene dibromide. High ammonia nitrogen however appears satisfactory for tobacco and pineapple, which generally show excellent response following fumigation. Good cultural practices, as well as disease and insect control must be observed in order to obtain maximum benefits from soil fumigation.

More than one nematode species often is encountered in a problem field. Because of the differences in the susceptibility of the various species to a given fumigant material one should know the pests involved. The root lesion, stubby root, or other species of nematodes, for instance, may not be controlled at the dosages used for the control of the root-knot nematodes.

The various fumigants also show a certain specificity as regards the control of different nematode species. For example, ethylene dibromide is considered more effective for the control of the potato rot and sting nematodes than dichloropropene-dichloropropane mixture. The latter is more effective against the encysted stages of such species as the sugar beet nematode. The larvae of the root-knot nematode are readily controlled by both; however, dichloropropene-dichloropropane mixture is considered more effective against the eggs. Thus the nematode species as well as the various life stages involved may determine the fumigant and dosage to be used for a particular problem. Methyl bromide seems to be effective over a wider range of pests than the other fumigants; however, the dosages used are generally higher.

The time of sampling for nematodes is very important not only for determining the presence of a nematode problem but also for evaluating soil fumigation results. In Michigan the root lesion and stubby root nematodes in some situations are found abundant in spring and early summer, but scarce or absent later in the season. It is felt that this may be associated with soil temperature and moisture conditions.

It has been found that nematodes are seldom uniformly distributed but generally occur in scattered areas throughout the field. Unless experimental plots are properly randomized significant results often cannot be shown because of extreme variations between replicates even though yield differences between treatments may be large.

The exact formulation of the fumigant used should be known and applications should be made on the basis of the active ingredient. Ethylene dibromide formulations, for example, have been used under about a dozen different designations. It has been found desirable to report results in terms of the actual amount of ethylene dibromide applied.

The fumigant applicator, regardless of type, should be in first class working condition so uniform applications can be made throughout a series of experiments. To avoid plugged nozzles a good line filter is an essential part of any field applicator. The machine must be calibrated for each material, for often various formulations of the same chemical have different rates of delivery under similar conditions. The calibration should also be checked frequently to be sure proper dosages are being applied.

Consideration of all of these factors is important when comparing two fumigants such as dichloropropene-dichloropropane mixture and ethylene dibromide. Satisfactory results may be obtained in one instance and then under apparently similar conditions one or both of them may fail. It must be recognized, however, that each fumigant has different and specific physical and chemical properties and each behaves differently under a given set of conditions. However, at times all soil fumigants appear equally effective. The common range for optimum effectiveness is apparently quite narrow and this may account for the many variations in the results obtained from applications made under conditions that appear satisfactory. These conditions as well as the properties of the chemicals are important considerations when evaluating new soil fumigant chemicals under diversified field conditions.

The past crop history of a field should be known and considered in a soil fumigation program. Certain crops may allow for the buildup of a large population of nematodes and larger dosages of a fumigant may be required to reduce the population enough for satisfactory results.

Woody type roots will protect nematodes, and a longer time must be allowed for these roots to decompose before fumigation than for the softer more succulent type roots. There are indications that large amounts of undecomposed organic matter turned under just before fumigation interferes with the action of the fumigant. Another factor is that undecomposed roots may protect the nematodes inside them from the fumigant.

The subsequent crops also must be considered in the evaluation of soil fumigation results. For instance, nematode-resistant crop varieties have proved to be very useful aids in crop production in certain areas but often this resistance is expressed only against a certain nematode complex. This resistance may break down under high nematode populations or in another location where the nematode complex is different. The use of so-called resistant varieties, supplemented with soil fumigation, is often highly beneficial. The dosage of the fumigant used will depend on the severity of the nematode population and on the susceptibility of the crop to the pests. Perennial crops which need a longer period of protection require more complete initial nematode control than annuals and thus require higher dosages.

The many factors which influence the results from the application of soil fumigants make it necessary to study these chemicals in various areas in order to determine which fumigant should be used as well as the best conditions and methods of application for satisfactory results. Only when the effect of these factors and their interaction on the results obtained from application of soil fumigants are understood can a sound nematode control program be developed.

THE DOW CHEMICAL COMPANY

THE NEMATODE COMPLEX IN SOUTHERN GEORGIA

John H. Machmer

In dealing with Baermann separable nematodes one is constantly confronted with a complex both tedious to work with and difficult to separate into its components. No longer may we speak of "nematodes" and mean only the root-knot disease. Even more, we must not now speak only of stubby root, coarse root, root lesion, etc., nematode diseases. It is necessary to evaluate all of these diseases, their symptoms, and the associated nematode kinds quantitatively, when rating a plant, plot, field, or crop region. It has become our practice recently to rate root collections by scoring symptoms of the several diseases. However, in practical soil fumigation work root-knot symptomatology still remains an excellent and widely applicable diagnostic method.

Observations are reported chiefly on the following nematodes: Sting (*Belonolaimus*), dagger (*Xiphinema*), true spiral (*Helicotylenchus*), other spiral (*Rotylenchus* spp.), ring (*Criconemoides*), stubby (*Trichodorus* and *Paratylenchus*), meadow (*Pratylenchus* spp.) and root-knot (*Meloidogyne* spp.). These are the parasitic nematodes usually and abundantly encountered. Besides these eight groups possibly six to ten other genera could have been scored. It is problematical whether this could be done in routine work.

Most of you can well remember when the root-knot nematodes only were recognized, and those as a single form. Very often, nematodes were not considered at all..

Although the Baermann method has long been used by plant nematologists its recent application to crop-nematode evaluation methods now makes it to the nematologist what the culture plate has long been to the plant pathologist. Perhaps many nematological opinions based on other than the Baermann technique are or should be reconsidered.

The material presented in tabular form herewith is entirely preliminary, and is intended merely to illustrate the variety and complexity of the problems encountered and the intensive work required in their study.

Table 1. Predominance of ring nematodes in the nematode complex of the Georgia peanut region, as shown by occurrence in samples from the sources indicated, collected from June to October, 1953.

Nematode	Average number of nematodes per standard Baermann sample of 15 cu. in.				Total nemas scored and counted	Sample frequency
	Region: 28 samples: 25 farms: 14 counties	Station: 43 samples: 27 plots	Experiment: 64 samples: 8 treatments	All sources: 135 samples: 53 locations		
PARASITIC						
Sting (Belonolaimus)	5[d]	0	0	1 (-)	130	2
Dagger (Xiphinema)	59	5	0	14	1,850	19
Spiral, true (Helicotylenchus)	8	4	--[a]	3	360	8
Spiral, other (Rotylenchus spp.)	22	8	51	31	4,240	57
Ring (Criconemoides spp.)	162	132	107	126	17,060	112
Stubby (Trichodorus, -- and Paratylenchus or "Pin")	23	15	34[a]	25	3,440	65
Meadow (Pratylenchus spp.)	48	55	--[a]	28	3,720	70
Root-knot (Meloidogyne arenaria)	121[b]	0	0	25	3,400	5
Total parasitic	448	219	192	253	34,200	
Percent Ring	36	60	56	50	50	
SAPROPHYTIC AND PREDACEOUS						
Dorylaimus and Mononchus	274	247	119	192	25,900	120
SAPROPHYTIC, SCAVENGER, AND MISCELLANEOUS Not Scored[c]	603	594	438	522	70,460	134
Total all Nematodes	1325	1060	749	967	130,560	135
Percent Ring					13	

[a] True Spiral and Meadow combined with Stubby under "Experiment".

[b] Root-knot from three farms 5 samples only, in the upper peanut area in the Chattahootchee Valley.

[c] Chiefly Diploscapter, Diplogaster, Acrebeloides, Rhabditis, miscellaneous, saprophytic, Cephalobus, and unscored or unidentified parasitic including Aphelenchs, etc., besides Tylenchs. Of these Rhabditis and Acrebeloides occur most commonly.

[d] Two samples, one field only.

Table 2. Nematodes associated with cotton in southern Georgia. Number of nematodes obtained from 15-cu. in. standard Baermann samples collected from 16 experiments and from 20 farms in 11 counties, total 41 samples (360 hills).

Nematode	Total no. estimated from 10% scores	Average number per sample all 41 collections	Number samples containing	Average number in samples containing	Percent of total parasitic
Total	56,930	1389	-	-	-
Sting[a]	480	12	3	160	2.1
Dagger	1,800	44	19	95	7.8
True spiral	2,740	67	12	228	11.9
Other spiral	580	14	5	116	2.1
Ring	670	16	17	39	2.1
Stubby	3,500	85	33	106	10.4
Meadow	3,460	84	33	105	10.7
Root-knot[b]	8,620	210	21	411	37.6
Dorylaims and mononchs	10,480	256	40	262	-
Other miscellaneous	23,560	575	41	575	-

[a] Late season collection may account for relatively small number of sting nematode.

[b] Descending order of prevalence: root knot, stubby, meadow, true spiral, dagger.

Table 3. Nematodes associated with 16 common weeds, with kind and severity of accompanying root symptoms[a].

Host	Total no. nematodes (estimated from 10% scroes)	10% level scores[a]							Root symptoms and severity[b]		
							Miscellaneous				
		Dagger	Ring	Stubby	Meadow	Root knot	Dorylaimus Mononchus	Other	Root-knot	Coarse root	Root lesion
Aster ericoides	920	2	1	1	4	12	33	39	Z	Z	L
Diodia teres	310	0	1	1	0	2	9	18	Z	M	M
Ambrosia artemisiifolia	1540	1	1	0	6	25	52	71	L	Z	H
Aplopappus divaricatus	1250	0	0	2	4	22	36	61	L	Z	L
Gerardia tenuifolia	2160	3	3	4	16	44	57	89	Z	Z	M
Hypericum gentianoides	640	1	1	0	0	12	25	25	Z	Z	M
Aristida	5260	3	13	6	39	52	197	216	L	L	H
Andropogon virginicus	2530	2	8	6	11	25	77	124	M	L	H
Cyperaceae (Cyperus, large)	3630	0	15	8	7	30	100	203	H	L	Z
Eupatorium tenuifolium	2520	3	3	2	9	21	84	130	Z	Z	L
Richardia scabra	1270	0	0	2	2	25	29	69	Z	Z	Z
Heterotheca subaxillaris	2380	1	3	1	5	20	69	139	Z	Z	Z
Paspalum sp.	1670	0	1	2	5	6	63	90	L	Z	Z
Digitaria sanguinalis	5300	9	13	13	24	124	141	206	H	L	L
Cyperaceae (Cyperus, small)	4820	1	4	6	9	16	204	242	Z	Z	Z
Cynodon dactylon	2960	2	1	12	11	65	82	123	L	L	L
Total at the 100% level	39160	280	680	640	1520	5010	12580	18450			

[a] Average scores of 2 15-cu. in. Baermann samples (20 hills) processed 40 hours, September 1953.

[b] Z = None; L = light; M = moderate; H = heavy.

Table 4. Nematode control vs. fertilizer application as means of prolonging productive period of Louisiana white clover in the southern Georgia Native Flat Woods Range[a]. Total number of nematodes (from 10 percent evaluation levels) per average 15 cu. in. Baermann sample per treatment plot, thrice replicated. (November 1952 to September 1953).

TREATMENT Time of collection	No. samples	Number of nematodes								
		Sting	Dagger	True Spiral	Other spiral	Ring	Other parasitic[b]	Dorylaims and Mononchs	Miscel-laneous	Total (average) per sample
NOT FUMIGATED										
Preplant collection Nov. 19, Nov. 26, Dec. 9, 1952	30	53	82	44	41	19	64	99	242	669
FUMIGATED										
Preplant collection Dec. 9, 1952	6								19	19
NOT FUMIGATED										
Growth period Apr. 1, May 18, June 22, 1953	18	12	116	5	204	9	--[c]	153	441	944
Dormant period Sept. 21 (after 6 weeks grazing Aug. 1-Sept. 21, 1953)	6	28	147	88	377	0	64	283	578	1564
FUMIGATED										
Growth period (as above)	18							27	363	389
Dormant period (as above)	6				15		20	177	975	1187
WITH FERTILIZER (Fumigated and not fumigated) Growth period (as above)										
100 lbs/A 16 X	18	8	63	5	113	6	--[c]	89	411	702
1600 lbs/A 1 X	18	3	52	0	85	4	--[c]	90	393	632

a In cooperation with RF Suman, Range Conservationist, U. S. Southeastern Forest Experiment Station.

b Including Stubby, Meadow, and others.

c Very few, calculated with miscellaneous.

Table 5. Nematode control vs. fertilizer application as means of prolonging productive period of Louisiana white clover in the southern Georgia Native Flat Woods Range[a]. Vigor ratings and weed control during growth period (April to September 1953).

Treatment	Vigor ratings[b] (average of 6)			Percent growth in plot area	
	April 1	May 15	Sept. 21[c]	Living clover June 22	Weeds Sept. 21
NOT FUMIGATED	1.7	1.7	1.0	48	13
FUMGATED	3.3	3.6	3.6	85	6
FERTILIZER 16 X	2.7	2.5	2.2	68	11
FERTILIZER 1 X	2.3	2.8	2.5	66	9

[a] In cooperation with RF Suman, Range Conservationist, U. S. Southeastern Forest Experiment Station.

[b] 1 = poor to 4 = excellent

[c] After 6 weeks grazing, Aug. 1 to Sept. 21.

GEORGIA COASTAL PLAIN EXPERIMENT STATION AND NEMATOLOGY SECTION, HORTICULTURAL CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE, TIFTON, GEORGIA

THE PLANT DISEASE REPORTER

Issued By

PLANT DISEASE EPIDEMICS
and
IDENTIFICATION SECTION

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

HELMINTHOSPORIUM PROBLEMS

Supplement 228 October 15, 1954

The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Plant Disease Epidemics and Identification Section serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

PLANT DISEASE REPORTER SUPPLEMENT

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Horticultural Crops Research Branch
Plant Industry Station, Beltsville, Maryland

Papers From The Symposium On

HELMINTHOSPORIUM PROBLEMS

presented at the Dallas meeting
Southern Division, American Phytopathological Society
Dallas, Texas, February 1-3, 1954

Plant Disease Reporter
Supplement 228

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APPROACHES TO THE CLASSIFICATION OF HELMINTHOSPORIUM SPECIES

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Although the taxonomic situation in Helminthosporium is no worse than in many other large genera of the Fungi Imperfecti, it is hardly necessary to state that problems exist or to argue for the need of further taxonomic study and revision. There has never been any attempt at a comprehensive treatment of Helminthosporium, not even of the species on grasses and cereals, the group of particular interest at the moment. A basis for study in this group has been laid in the excellent paper on graminicolous Helminthosporia by Drechsler (1). However, Drechsler did not include all of the species known to occur even in the United States at that time, and his work was published over thirty years ago.

At present there are slightly over 100 described species on grasses and cereals. These represent less than one-fourth of the total number in the genus. Certainly there are more than 450 names in Helminthosporium, and the number may approach 500. In addition to the graminicolous species there is a relatively small group which occur as hyperparasites on sooty mold fungi. There is also a large group of species which grow saprophytically on dead wood. Finally, there is another large group of species which are certainly or possibly parasitic on dicots or monocots other than grasses. Many of these are of economic importance. Helminthosporium papulosum Berg, cause of black pox of apples, for example, is now attracting attention in North Carolina and Georgia.

In a recent paper Hughes (4) expressed the opinion that the graminicolous species are incorrectly placed in Helminthosporium since they differ in what he considers to be fundamental characteristics from Helminthosporium velutinum Link ex Fr., the type species of the genus. H. velutinum is a member of the group occurring on old wood. There also appears to be some confusion as to the characters distinguishing Helminthosporium from other genera such as Napicladium, Brachysporium, and Curvularia. This indicates that questions of generic separations are involved, and it will be necessary to determine the relationships of the graminicolous species to other species in Helminthosporium and related genera. On the other hand, it might be inferred from Hughes' (4) study that the species on grasses represent a distinctive group which, temporarily, may be considered independently.

Compilation

There are no startlingly new approaches to the classification of Helminthosporium species. The only approach is persistent routine work of a nature which most find rather tedious. A first step toward a reorganization of the graminicolous species is an assessment of the present situation through a compilation of the literature dealing with these species. Even an alphabetical list of species would be helpful. Such a list must include all species of the genus. There are, for example, three fungi named Helminthosporium panici Two of these, H panici Van Overeem (15) and H. panici Sawada (10), are parasites on Panicum. The third species, and the one which has priority, is H. panici F. L. Stevens(13). Stevens' fungus is one of the hyperparasites on Meliola spp. A compilation of original descriptions of at least the graminicolous species would be desirable. A tentative key to species might also be attempted . Such a key would prove useful primarily in indicating possible relationships among species and in bringing together groups of similar species which should be subjected to comparative study. A key might also focus attention on the essential diagnostic characters. Species descriptions are still appearing in which no mention is made of important characters.

Type Collections

Since many of the original descriptions are completely inadequate, a study of type collections is essential. Many of the type collections are unobtainable, and some of those which can be located are nearly worthless. Even when the material is well preserved, it is difficult to determine such characters as type of germination and wall thickness of the dried conidia. Of course, it is impossible to determine pathogenicity. Even when type cultures have been preserved, these have often lost their virulence or ability to sporulate. Nevertheless, with these limitations, the study of type collections will prove profitable. The name Helminthosporium nodulosum B. & C. ex Sacc. (9), for example, was originally given to a fungus Curtis collected on Eleusine indica in South Carolina. More recently this name has been applied to a fungus pathogenic to Eleusine

coracana in Africa and India. The descriptions of Butler as cited by Sprague (12) and of Mitra and Mehta (6) are sufficient to indicate that the Indian fungus belongs among the group of species which might be termed the Helminthosporium oryzae-sacchari complex. H. nodulosum as represented in the type collection, which is preserved both in the Farlow Herbarium and at Kew, is, however, an entirely different fungus. It is very closely related to H. leucostylum Drechs. (1). This and other examples which could be cited illustrate the confusion in the application of names resulting from failure to consult readily available types.

Morphology

Thirdly, the range of variation within species and the proper delimitation of species should be determined by study of mass collections of field material. If, for example, the type of collections of Helminthosporium sorokinianum Sacc. ex Sorokin (11) and H. sativum P. K. & B. (7) are examined, differences in conidial shape and dimensions sufficient to distinguish the two species are apparent. However, study of a series of collections of fresh material has shown that there occur in the field specimens nearly identical with the type of H. sorokinianum, specimens nearly identical with the type of H. sativum, and specimens representing all intergradations between these two extremes. It now appears impossible to separate these two species satisfactorily. Parris (8) has published work of a similar nature on Helminthosporium sacchari (Van Breda de Haan) Butler.

Morphological studies of field material should be supplemented by cultural studies. Such studies should be made of the "wild types" as suggested by Miller (5) for Fusarium spp. It hardly seems necessary, so far as the pathologist is concerned, to attempt to classify the numerous cultural variants which have not been found in nature. The simplest method of maintaining isolates in their original form seems to be the method of soil culture revived by Miller (5) for the storage of Fusarium spp. A number of isolates of Helminthosporium sativum and H. victoriae Meehan & Murphy have been kept in tubes of soil at room temperatures without transfer for more than two years without loss of viability or original characteristics.

Conidia produced in culture show less variation than those formed under diverse conditions in nature. Cultural study, therefore, may assist in placing extreme forms which are sometimes found in field collections. Conidia in a collection of H. victoriae on oat culms made in South Georgia during hot, dry weather were straight, extremely thick-walled, and dark colored, and in these respects closely resembled the conidia of extreme forms of H. sativum. However, conidia produced in culture by isolates from this collection were typical of the thinner-walled, paler-colored conidia of H. victoriae.

In order to insure comparable results the method of producing conidia in culture should be standardized. Although the wounded-agar plate method has been satisfactory for inducing the sporulation in most species, conidia of some strains under these conditions are decidedly abnormal. The most satisfactory method tried is that proposed by Hansen and Snyder (3). Barley straw, coarsely ground in a Wiley mill, is placed with one cc. of propylene oxide in a quart jar which is then sealed for 24 hours. The gas-sterilized straw is scattered over the surface of plain water agar plates. The plates are inoculated at several points and incubated at a constant temperature of 20°C with exposure to normal day-light and darkness for two weeks. The conidia are comparable to those produced in nature. This method has been successful even with such difficult species as Helminthosporium gramineum Rab. It has failed only with H. siccans Drechs.

Cultural studies such as those of Elliott (2) in which factors of nutrition, temperature, light, and humidity are varied may provide information on the causes of variation in the field and assist in determining the relative value of various diagnostic characters. Tinline's (14) demonstration of sexual strains in Helminthosporium sativum suggests the further possibility of using genetic data in determining taxonomic relationships.

Pathogenicity

Finally, pathological studies must be made in conjunction with morphological studies. Since the pathologist is interested in species of Helminthosporium primarily as causes of disease in crop plants, a practical system of classification must express differences in pathogenicity among these forms. H. victoriae is of economic importance as a cause of a severe seedling blight of certain oat varieties. The pathologist, therefore, is under the practical necessity of recognizing this fungus. He may be inclined to separate this species on the basis of pathogenicity and to search for even minor differences that might be used to distinguish it from morpholo-

gically related forms. Wehmeyer (16) has made a valuable contribution in demonstrating that there is so little morphological difference among the Pleospora perfect stages of graminicolous species of Helminthosporium that all may be referred to the single species P. trichostoma (Fr.) Ces. & De Not. However, since these forms cause different diseases and in the conidial stage may be distinguished, even if by minor morphological differences, there is justification on utilitarian grounds for recognizing several species such as H. bromi Died., H. avenae Eidam, H. teres Sacc., and H. tritici-repentis Died., along with the corresponding perfect stage names. On the other hand, it may be convenient for the pathologist to regard as the same species forms on different hosts which cross-infect, even if considerable morphological variation exists.

In the classification of fungi of economic importance an attempt should be made to devise a system of the greatest practical usefulness, even if it is necessary to employ criteria different from those used in more obscure groups or groups of lesser importance. The extent to which tests for physiological characteristics should be used in recognizing species depends more on convenience than on any arbitrary decision as to whether characters should be considered morphological or physiological or what emphasis should be placed on either category.

Literature Cited

1. Drechsler, C. 1923. Some graminicolous species of Helminthosporium. Jour. Agric. Res. 24: 641-739.
2. Elliott, E. S. 1949. The effect of the sugar concentration on conidial size of some species of Helminthosporium. Phytopath. 39: 953-958.
3. Hansen, H. N., and W. C. Snyder. 1947. Gaseous sterilization of biological materials for use as culture media. Phytopath. 37: 369-371.
4. Hughes, S. J. 1953. Conidiophores, conidia, and classification. Canadian Jour. Bot. 31: 577-659.
5. Miller, J. J. 1946. Cultural and taxonomic studies on certain Fusaria. I. Mutation in culture. II. The taxonomic problem in Fusaria with particular reference to the section Elegans. Canadian Jour. Res., Sec. C, 24: 188-212, 213-223.
6. Mitra, M., and P. R. Mehta. 1934. Diseases of Eleusine coracana Gaertn., and E. aegyptiaca Desf. caused by species of Helminthosporium. Indian Jour. Agric. Sci. 4: 943-975.
7. Pammel, L. H., C. M. King, and A. L. Bakke. 1910. Two barley blights, with comparison of species of Helminthosporium upon cereals. Iowa Agric. Exp. Sta. Bull. 116: 178-190.
8. Parris, G. K. 1950. The Helminthosporia that attack sugar cane. Phytopath. 40: 90-103.
9. Saccardo, P. A. 1886. Sylloge fungorum 4.
10. Sawada, K. 1943. Rept. Govt. Inst. Formosa 85: 96 (In Japanese).
11. Sorokin, N. 1890. Some diseases of cultivated plants in the southern Ussurian region. Proc. Biol. Soc. Imp. Univ. Kazan 22: 3-32 (In Russian).
12. Sprague, R. 1950. Diseases of cereals and grasses in North America. Ronald Press Co., New York.
13. Stevens, F. L. 1918. Some meliolicolous parasites and commensals from Porto Rico. Bot. Gaz. 65: 227-249.
14. Tinline, R. D. 1951. Studies on the perfect stage of Helminthosporium sativum. Canadian Jour. Bot. 29: 467-478.
15. Van Overeem, C. 1925. Beitrage zur Pilzflora von Niederlandisch Indien. II. 11. Über eine verheerende Helminthosporiose des bengalischen Grases (Panicum maximum Jacq.). Bull. Jard. Bot. Buitenzorg. Ser. III. 7: 431-434.
16. Wehmeyer, L. E. 1949. Studies in the genus Pleospora. I. Mycologia 41: 565-593.

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VARIATION IN PATHOGENCITY IN THE HELMINTHOSPORIUM BLIGHT ORGANISM OF OATS AND EVIDENCE FOR ITS RELATIONSHIP TO H. SATIVUM

H. R. Rosen

In 1946 evidence was presented in the Plant Disease Reporter (vol. 30 (10): 366-368) indicating that Helminthosporium blight of oats is not confined to Victoria derivatives. It was noted that Bond and some of its hybrids are not immune although they are highly resistant. This has been confirmed recently by W. C. Paddock (Cornell Agr. Exp. Sta. Memoir 315, 1953. p. 16).

In the fall of 1953 several single-spore isolates from a blighted Traveler plant (a Victoria derivative), when inoculated as a spore and mycelial suspension in sterile water on seedlings of a Bond derivative (R 22-66-53) and on several related derivatives, produced marked infections mostly confined to the distal ends of blades. These selections, when inoculated with other isolates, had previously shown a high degree of resistance to blight. On R 22-66-53, the infections often involved one-third to one-half of the blades and consisted at first of grayish-green collapsed tissue which within a few days turned brown. When such infected plants are placed in a moist chamber for 48 hours, the fungus covers the infected areas with a heavy mycelial growth readily observed on the surface of the leaves, much like that obtained on susceptible Victoria derivatives treated in a similar manner. When 100 seeds of this selection were inoculated with a spore and mycelial suspension, there was a 30.8 percent in stand compared with uninoculated seed, and this compared with 12.5 percent loss in stand of De Soto (a Victoria derivative) and an additional 14 percent loss in the latter from post-emergence blight. There was no post-emergence blight in R 22-66-53 although the total percentage of loss of plants was greater in this Bond derivative than in De Soto. The experiment involving seedling inoculations was repeated and essentially the same results were obtained. Thus there appears to be no doubt that there are strains or races of the blight organism that are capable of producing severe infections on oat varieties and selections that have no known Victoria inheritance.

It was also noted in the 1946 article previously cited that the variety Markton is susceptible, as well as Winter Turf 435-4. It may now be stated that the inclusion of Markton was probably an error occasioned by the presence of a relatively large number of rogues. In addition to oats, it was likewise noted that the barley varieties Fayette and Texan, when artificially inoculated, developed small dark brown or smallish spots on leaves of seedlings, much like those produced by Helminthosporium sativum but more restricted in size of spots.

In view of this evidence, plus the fact that spore measurements of conidia, color of spores, and polar germination of such spores, all indicated kinship to H. sativum, I have been reluctant to accept the name H. victoriae Meehan & Murphy and have recently reduced it to a varietal status (H. sativum var. victoriae (n.c.) Arkansas Agr. Sta. Bul. 533, 1953, p. 22).

In the earlier work of Dr. H. C. Murphy and his students (Science 104: 413-414, 1946; Phytopath. 37: 790-800, 1947) no mention is made of susceptibility to blight other than in Victoria derivatives. This was considered to be so highly specific for Victoria derivatives that when one of his students (Litzenberger, S. C. Iowa Agr. Exp. Sta. Res. Bul. 370, 1949) found susceptible plants in progenies of Mindo x Landhafer, "it was assumed that these were the result of natural crossing with plants susceptible to H. victoriae." Of course it could just as readily be assumed that there was no out-crossing and that there are strains or races of the blight organism fully capable of infecting plants that have no Victoria genes for susceptibility to blight.

That there are marked morphological differences in different isolates of the blight pathogen has been noted by almost all who have worked with this parasite for any length of time. Aside from saltations or mutations that are common in single spore cultures of many Helminthosporium species, differences have been noted in color and size of mycelium, in ability to produce conidia, and in color, measurements, and thickness of wall of conidia in the oat blight organism.

The difficulty experienced by Dr. R. W. Earhart in identifying the species of Helminthosporium that produces a culm rot on Southland oats (Phytopath. 43: 516-518, 1953) is to be expected so long as it is assumed that Helminthosporium blight is confined to Victoria derivatives. Southland represents a selection made by W. H. Chapman from the cross (D 69 x Bond) x Fultex (Florida Agr. Exp. Sta. Circ. S-18, 1950). Fultex represents a cross, Fulghum x Victoria, so that Southland presumably has both Bond and Victoria in its heritage. But Chapman found Southland to be resistant to blight, although he noted "some lodging due to a condition of

undetermined origin", and he also found it to be resistant to race 45 and related races of crown rust (Puccinia coronata). Since Murphy and his students have clearly shown a linkage between susceptibility to blight and resistance to race 45 of crown rust in Victoria derivatives, Earhart faced the almost impossible task of deciding what species of Helminthosporium incited culm rot on Southland. As this variety is resistant to both blight and race 45, it could not be considered as possessing typical Victoria genes, and without these, how could it be susceptible to an Helminthosporium culm rot unless one considered this rot to be caused by a wholly different species? Earhart partly solved this dilemma by identifying his isolates tentatively as H. sativum.

There is one other bit of evidence which leads me to conclude that the oat blight organism is related to H. sativum. Ito and Kuribayashi (Jour. Facult. Agr. Hokkaido Imp. Univ., Sapporo, 29: 85-125, 1931) described the perfect stage of H. sativum as Ophiobolus sativus, which they obtained in pure culture on rice-culm decoction agar. Apparently they did not collect this stage on natural hosts and I do not know of any such collections made elsewhere. Since the fall of 1945, a search has been made for the perfect stage of the oat blight organism on stubble and straw of varieties that had shown blight. Only one perithecium was found (University Farm, Fayetteville, Arkansas, January 7, 1947) which morphologically resembled O. sativus. It was found near the base of a leaf sheath of Traveler straw and was a dark, flask-shaped structure with no setae, measuring 384 x 240 microns. There were numerous asci and ascospores, the former appearing as worm-shaped threads, light yellowish-brown in color, rounded at the apex, tapering markedly at the base, with very short stipes, measuring 98-165 x 3.8 microns. The ascospores were much coiled or spiral shaped, exceedingly thin, colorless threads measuring 56-79 x 0.5 microns, easily broken into short segments by movement of the cover glass on the microscopic mount. These measurements derived from a single perithecium probably have little significance and are smaller than those given by Ito and Kuribayashi for O. sativus. But the flask-shaped perithecium without setae and the coiled ascospores which readily break into short segments are very distinctive characters found in O. sativus cultured from diseased barley and wheat in Japan.

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VARIATIONS WITHIN SPECIES OF HELMINTHOSPORIUM

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Variation in cultural behavior and virulence is a commonly observed phenomenon within the species of *Helminthosporium* actively pathogenic on corn. Robert (4) studied variability in cultural behavior and virulence among single-spore and hyphal-tip isolates of *H. turcicum* Pass. Variation in cultural behavior was expressed as colony color, type of mycelial growth, production of conidia, and growth rate. Wide variations were found in virulence. Specialization in parasitism was not studied. The variants were unstable in both cultural characters and virulence. Robles (5) reported two pathogenic races in *H. turcicum* based on their behavior on 11 varieties of corn in the seedling stage. In the writer's experience with a relatively large number of isolates of the fungus and many inbred lines, hybrids and open-pollinated varieties, seedlings have been uniformly susceptible; resistance was not expressed until plants were several weeks old. Specialization in parasitism among cultures of *H. turcicum* isolated from corn has never been observed by the writer. Inoculum taken directly from lesions of diseased leaf collections has always been highly virulent. In general the longer isolates have been in pure culture and the more frequently they have been transferred, the greater has been the variation in cultural behavior and virulence.

Despite the results with different lines of corn there is definite evidence of specialized parasitic races within *H. turcicum*. Mitra (2) observed the difference in parasitism between isolates from corn and those from sorghum. Lefebvre and Sherwin (1) pointed out that races within the species could be distinguished on the basis of their ability to attack corn, sorghum, Sudan grass, and Johnson grass. Two cultures from Sudan grass and one from sorghum were pathogenic on Sudan grass and sorghum, but failed to infect corn. Four of the cultures from corn infected Sudan grass, two did not, but all six were highly pathogenic on corn. A culture from Johnson grass was pathogenic only on its own host. Thus four distinct parasitic races were demonstrated among ten isolates.

Variation in cultural behavior has been shown in *H. maydis* Nisikado & Miyake (3). In the writer's experience this species is the most variable in cultural characters of those discussed here. The virulence of the isolates has remained stable, but detailed studies in this respect have not been undertaken. Specialization in parasitism has not been demonstrated within the species.

Helminthosporium carbonum Ullstrup appears to consist of two races that may be distinguished by their specialization in parasitism toward certain inbred lines of corn, their relative virulence, and symptoms incited on leaves (6). Race I is highly virulent and capable of complete destruction of suscepts. Susceptibility to this race is relatively rare as resistance is governed by a single dominant gene (7). Resistance and susceptibility to this race are demonstrable at all stages of host development. Race II is mildly virulent, and shows no pronounced specialization in parasitism, and host resistance is probably polygenic. Within both races cultural variants arise commonly in pure culture, but in Race I variation in virulence has not been observed.

Literature Cited

1. Lefebvre, C. L. and H. S. Sherwin. 1945. Races of *Helminthosporium turcicum*. (Abstract). Phytopath. 35: 487.
2. Mitra, M. 1923. *Helminthosporium* spp. on cereals and sugarcane in India. Part I. (Diseases of *Zea mays* and *Sorghum vulgare* caused by species of *Helminthosporium*.) India Dept. Agr. Mem., Bot. Ser. 11 (10): 219-242.
3. Mitra, M. 1931. Saltation in the genus *Helminthosporium*. British Mycol. Soc. Trans. 16: 115-127.
4. Robert, A. L. 1952. Cultural and pathogenic variability in single-conidial and hyphal-tip isolates of *Helminthosporium turcicum* Pass. Tech. Bul. 1058: 18 pp.
5. Robles, L. H. 1949. The pathogenicity of species of *Helminthosporium* on corn. Phytopath. 39: 1020-1028.
6. Ullstrup, A. J. 1944. Further studies on the species of *Helminthosporium* parasitizing corn. Phytopath. 34: 214-222.

7. Ullstrup, A. J., and A. M. Bronson. 1947. Linkage relationships of a gene in corn determining susceptibility to a Helminthosporium leaf spot. Jour. Amer. Soc. of Agron. 39: 606-609.

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HELMINTHOSPORIUM DISEASES ON CORN

Arnold J. Ullstrup

There are three distinct and economically important diseases of corn in the United States incited by species of Helminthosporium.

Helminthosporium turcicum Pass. is the inciting agent of northern corn leaf blight. Conidia are olive-gray, spindle-shaped, often curved on one side, average 105 x 20 microns in size and have 1 to 9 septa. The hilum is conspicuous. No sexual stage of the fungus is known.

Symptoms appear as long elliptical, grayish green to tan spots, ranging up to 6 x 1.5 inches in size. Spores are produced on the surfaces of the lesions in damp weather. During severe outbreaks leaves may be nearly completely covered with lesions, leaving little green tissue. Observations in both naturally and artificially induced epiphytotics indicate that the disease does not attack ears, so that the possibility of seed transmission is very remote.

Northern corn leaf blight is found throughout most of the eastern half of the United States. Relatively cool weather accompanied by frequent heavy dews seems to favor spread and development of the disease. Warm, dry weather definitely checks it.

Resistance to infection by H. turcicum appears to be governed by a relatively large number of genes (1, 2). Resistance is not manifested until plants are several weeks old. Some of the sources of resistance which have been used as parental material are NC34, Mo21A, L97, Ky114, and C123. Very little resistance is present among the hybrids used commercially in the Corn Belt.

Helminthosporium maydis Nisikado & Miyake is the inciting fungus of southern corn leaf blight. Conidia are pale smoky-colored to olive-brown, average 90 x 115 microns in size, with 3 to 13 septa, and exhibit greater curvature than any other species attacking corn. The hilum is inconspicuous. Perithecia of the sexual stage, Cochliobolus heterostrophus Drechs., are black, beaked, and 0.4 to 0.6 mm in size. Asci measure 160-180 x 24-28 microns, and contain up to eight, but typically four ascospores. Ascospores are pale smoky-colored, 130-340 x 6-7 microns, 5-9 septate, in a helicoid arrangement within the asci. The sexual stage appears not to be abundant in nature, and its role in the progagation of the species may be unimportant.

Southern corn leaf blight occurs generally in eastern United States from the Ohio River Valley southward. The disease is favored by humid weather and appears to thrive at a somewhat higher temperature than is optimum for northern corn leaf blight.

The symptoms, which are readily distinguished from northern corn leaf blight, appear as elongated, tan lesions with generally parallel sides, that range up to 1-2 x 1/4-1/2 inches in size. The size, shape and color of the lesions may vary somewhat between different inbred hosts. Lesions on some inbred lines show a distinct, narrow, purple margin. Ears are not often infected.

Resistance, which is not expressed until plants are several weeks old, is manifested as small pale flecks where penetration has taken place. Resistance appears to be determined by several genes (3). Among the most resistant inbred lines of Corn Belt maturity are C103, Tr, Os426, and MoG.

Helminthosporium carbonum Ullstrup, the fungus inciting Helminthosporium leaf spot, appears to consist of two pathogenic races which are indistinguishable on the bases morphology, cultural behavior, or symptoms induced on corn ears. The two races are separable on the basis of leaf symptoms, virulence, and specialization in parasitism on inbred lines (5). Conidia are spindle shaped, straight to lightly curved, olivaceous brown, 2-12 septate, and average 62 x 13 microns in size. No sexual stage of the fungus is known.

Symptoms produced on suscepts following infection by Race I appear as tan, oval, zonate spots ranging up to 1 x 1/2 inch in size. The reaction on resistant hosts to infection is manifested as pale minute flecks about 1 mm in size, at points where the fungus has penetrated but its progress arrested. All parts of susceptible plants, including ears, may be attacked. The ears have a black, charred appearance. Race I is highly virulent and, under optimum conditions, suscepts may be killed before ear formation. As a consequence of ear infection the disease is readily disseminated through seed. Reaction of inbred lines to infection by Race I may be readily ascertained in the young seedling stage. Resistance is determined by a single dominant gene located on chromosome 1 (6). The disease incited by Race I is unique in that susceptibility is comparatively uncommon. Because of dominance of resistance, hybrids are not attacked unless two homozygous susceptible inbreds are crossed. Obviously, such combinations would not be made if the disease reaction of the inbred lines were known. Inbred lines known to be susceptible, and which are being or have been used in hybrid production, are K61, K44, Pr, and Mo21A.

Symptoms produced on plants in the field following infection by Race II appear as elongated, chocolate-brown spots ranging up to 2 x 1/2 inches in size. Symptoms on ears are identical with those incited by Race I. Symptoms on young seedling leaves are recognized as small elongated, tan spots. The disease incited by Race II is seldom encountered and consequently is of little importance. Race II is only mildly virulent and has never been observed to be as destructive as Race I. The mode of inheritance has not been studied, but a number of genes appear to be involved.

Other species of Helminthosporium have been reported as parasitic on corn, but these appear to be of very minor consequence. H. rostratum Drechs. has been found on corn in Mississippi (7), but it appears to be of rare occurrence and not destructive. H. sativum P. K. & B. has been cited as a pathogen of corn (4), but observations suggest that the disease must be very rare and certainly of no economic importance.

Literature Cited

1. Jenkins, M. T. and A. L. Robert, 1952. Inheritance of resistance to leaf blight of corn caused by Helminthosporium turcicum. Agron. Jour. 44: 136-140.
2. Jenkins, M. T., et al. 1952. Inheritance of resistance to Helminthosporium turcicum leaf blight in populations of F3 progenies. Agron. Journ. 44: 438-442.
3. Pate, J. B. 1950. Studies on Helminthosporium maydis and H. carbonum leaf diseases of corn. (Abstract). Phytopath. 40: 790.
4. Robles, L. H. 1949. The pathogenicity of species of Helminthosporium on corn. Phytopath. 39: 1020-1028.
5. Ullstrup, A. J. 1944. Further studies on the species of Helminthosporium parasitizing corn. Phytopath. 34: 214-222.
6. Ullstrup, A. J., and A. M. Brunson, 1947. Linkage relationships of a gene in corn determining susceptibility to a Helminthosporium leaf spot. Jour. Amer. Soc. of Agron. 39: 606-609.
7. Young, G. Y., et al. 1947. Helminthosporium rostratum on corn, sorghum, and pearl millet. Phytopath. 37: 180-183.

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THE PLANT DISEASE REPORTER

Issued By

PLANT DISEASE EPIDEMICS
and
IDENTIFICATION SECTION

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

SOME NEW AND IMPORTANT PLANT DISEASE OCCURRENCES AND DEVELOPMENTS IN THE UNITED STATES IN 1953

Supplement 229 December 15, 1954

The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Plant Disease Epidemics and Identification Section serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

THE PLANT DISEASE REPORTER

PLANT DISEASE EPIDEMICS AND IDENTIFICATION SECTION

Horticultural Crops Research Branch Plant Industry Station, Beltsville, Maryland

SOME NEW AND IMPORTANT PLANT DISEASE OCCURRENCES AND DEVELOPMENTS IN THE UNITED STATES IN 1953

Compiled by Nellie W. Nance

Plant Disease Reporter
Supplement 229 December 15, 1954

As in previous years this summary of outstanding plant disease occurrences in the United States has been taken for the most part from reports to the Plant Disease Epidemics and Identification Section and from articles in Phytopathology. Some 1952 records that had not appeared when the 1952 summary was completed are included. Reports listed in the tables are not generally listed in the text.

WEATHER OF 1953. General. -- Severe drought was the most notable and costly weather feature of 1953. Beginning in the western portions of the lower Great Plains during the spring months, it expanded over most of the Southern Interior by midsummer and over most of the remainder of the Country by early autumn. Losses to crops, pastures, and livestock and the added expenses caused by declining water supplies amounted to hundreds of millions of dollars. Despite the drought, however, total crop production was above the average owing to several favorable factors, among which were plentiful subsoil moisture in most northern areas during the growing season, adequate irrigation water in the far West, abundant rainfall in the far Southeast, early crop maturity, ideal harvesting weather, and the absence of damaging fall frosts.

A second outstanding feature was the great damage done by a record number of tornadoes, the paths of many of them running through large cities and densely populated areas in the Northeast. Among the unfortunate cities struck by these destructive storms were Waco, Tex., Flint, Mich., Cleveland, Ohio, and Vicksburg, Miss.

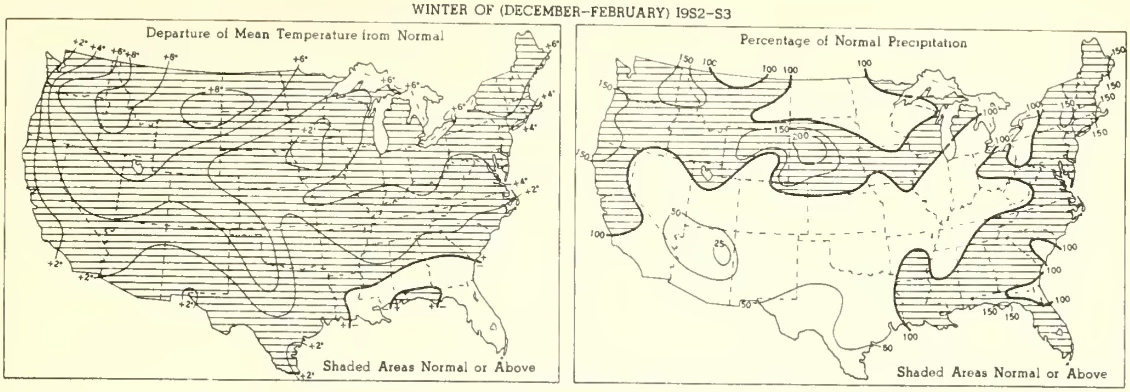
The nationwide precipitation average was more than an inch and one-half below normal, even though monthly averages were above normal in January, March, April, May, and December. The yearly averages were above normal in the Pacific Northwest, northern Great Plains, extreme upper Great Lakes, the Gulf region, extreme Southeast, and scattered sections along the Atlantic Coast. Excesses were greatest in the northern Great Plains where totals for the year ranged up to 150 percent of normal. In contrast, the year's precipitation was less than 15 percent of normal in the far southwestern desert areas, under 50 percent in all of southern California and parts of south-central and southwestern Texas, and less than 75 percent in a large midwestern area including western and southern Ohio, southern Indiana, southern Illinois, Missouri, southern Iowa, northern Arkansas, southern and eastern Kansas, and southeastern Nebraska.

The 1953 temperature for the United States averaged more than a degree above the long-term mean, with below average departures only from western Oregon southward through the central portion of California to Bakersfield, and in the San Diego area, eastern Arizona, west-central New Mexico, and parts of the extreme Southeast. The greatest positive departures, up to 4°, occurred in regions near the Canadian Border east of the Continental Divide. The nationwide average temperature was above normal for every month in the year, except April, May, and December.

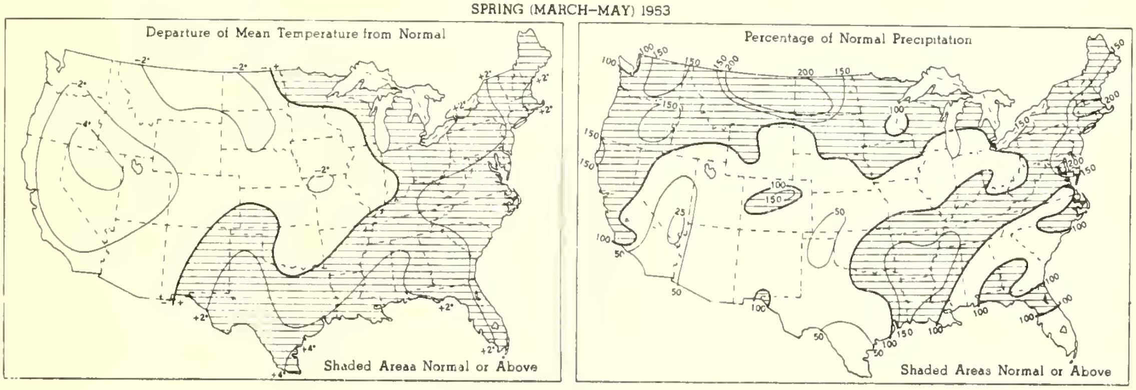
The first 3 months of the year were unseasonably warm, particularly January for which the nationwide temperature average was the highest on record. The ground remained unusually free of snow, and navigation began early in many northern lakes and streams. Precipitation during this period was about normal or slightly above. April and May were cold and wet. Growth of vegetation was retarded, farmwork delayed, and widespread frosts and freezes caused light to locally severe fruit damage in the far West and some damage in middle and southern areas east of the Rocky Mountains. Cooler than usual weather persisted through August in the Pacific States, although dry, sunny weather after June enabled crops to make good recovery from the cold, wet weather of spring. Heat and drought prevailed over large sections of the Country from June until late November when a return to near or above normal precipitation ended the drought in virtually all areas, although subsoil moisture and water supplies

TEMPERATURE AND PRECIPITATION

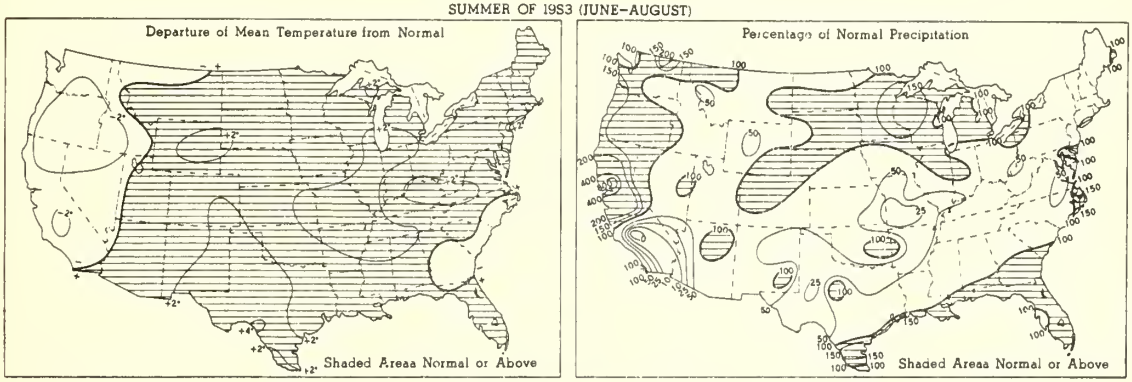
WINTER OF (DECEMBER–FEBRUARY) 1952–53



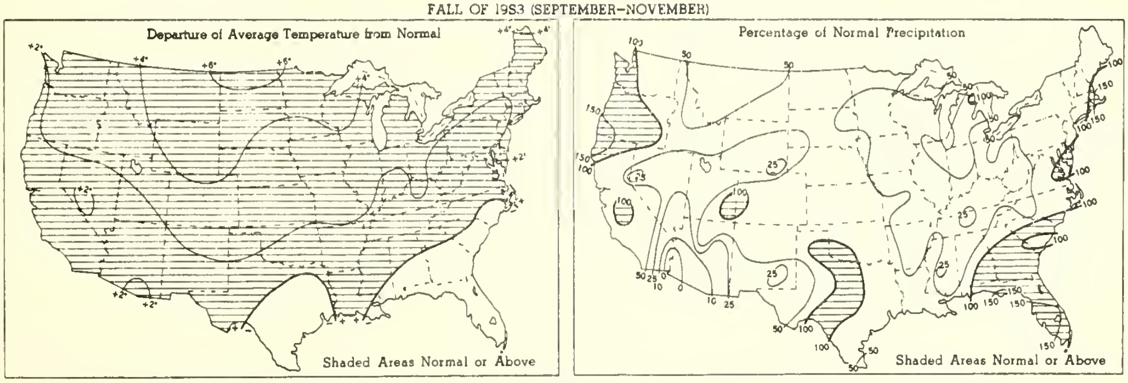
SPRING (MARCH–MAY) 1953



SUMMER OF 1953 (JUNE–AUGUST)



FALL OF 1953 (SEPTEMBER–NOVEMBER)



(From Weekly Weather and Crop Bulletin National Summary, Volume 40, 1953).

remained low in several sections from the east-central Great Plains eastward through the Ohio Valley and western Pennsylvania.

DROUGHT. -- The 1953 drought was notable for its complexity. After becoming intense in an area of significant size it would be broken, only to reappear later in the same area or to develop with similar intensity elsewhere. Drought first developed during the spring in the Southwest where scanty rainfall was a continuation of the dryness of the two previous years. A period of unusually hot, dry weather in the lower Mississippi Valley and east-central areas from May 19 to July 6 extended the drought coverage over practically the entire southern interior portion of the Country and it steadily increased in severity. For this 7-week period less than one-tenth of the normal rainfall was received in extreme southern, northern, and western Texas, some far southwestern districts, most of Oklahoma and Arkansas, extreme western Tennessee, and northwestern Mississippi. Pastures, small grains, corn, cotton, and other crops suffered severely in most of this region. Showers from June 27 to 29 brought limited relief to eastern Texas, Louisiana, and southern Mississippi; but it was not until after the first week of July that general showers over the Southern Interior brought considerable relief to most of this area, and it was yet later (with the heavy rains the last part of August and the first week of September) that the prolonged drought in the Rio Grande Valley was effectively broken.

The July and August rains generally missed the area from southeastern Nebraska and eastern Kansas eastward to Maryland, Virginia, and the Carolinas, resulting in a gradual build-up of severe droughty conditions in most of this region. The centers of severe dryness in this region were Missouri, the Ohio and middle Mississippi Valleys, West Virginia, and the central portions of Virginia and the Carolinas where pastures and other crops, especially corn, were damaged considerably, an extremely high fire hazard was created, and subsoil moisture and water supplies were seriously reduced.

Another hot, dry period from early September to mid-October intensified and extended the drought over practically the entire Country, except the far Southeast, middle and northern Pacific coastal sections, and a few local areas. During this period about one-half the total area of the Country received less than 25 percent of normal rainfall and some sections less than 10 percent. This severely afflicted area included the Ohio and middle Mississippi Valleys, most of Missouri and Iowa, a narrow belt extending from southern Minnesota southwestward to northern Nevada, extreme southern California and Arizona, and southwestern New Mexico.

Widespread rains in late October alleviated the drought from Virginia northward through New England and brought limited relief to an area extending from northern Mississippi, Arkansas, and Missouri to Michigan, western portions of the northern Great Plains, and middle Rocky Mountain sections. Moderate to heavy precipitation from the eastern Great Plains to the Atlantic Coast during the third week of November and the first week of December replenished topsoil moisture and improved water supplies, but in many sections from the east-central Great Plains eastward through the Ohio Valley into western Pennsylvania subsoil remained low and water hauling continued at the end of the year.

DESTRUCTIVE STORMS. -- The year 1953 was the severest on record for tornadoes. Of the seven outstanding tornadoes (see preliminary tabulation below), the one that struck in central and eastern Massachusetts on June 9 caused greater damage (expressed in dollars) than any other single tornado in the history of the United States. Total tornado damage for the year was about $224, 000, 000, a new record. These storms caused over 500 deaths and nearly 5, 000 injuries, most of which occurred in March, April, May, June, and December. The greatest monthly toll was in June when 244 deaths, 2, 644 injuries, and $96, 000, 000 property damage were reported.

Outstanding storms other than tornadoes included: Two violent windstorms which caused $12, 000, 000 damage in Kansas City, Mo., on June 21; one of the most destructive hailstorms on record, which caused $6, 000, 000 damage to standing wheat in the southwestern portion of the Nebraska Panhandle on July 2; $4, 250, 000 hail damage in Iowa on July 5; and a general cyclonic windstorm that resulted in more than $10, 000, 000 damage along the north Atlantic Coast on November 6 and 7.

The worst winter-type storm of snow, glaze, sleet, etc., occurred in the Northeast from January 7 to 11 when severe glaze caused losses estimated at more than $4, 000, 000. Other storms included a $250, 000 snowstorm in New England on April 13 and 14, and glaze that resulted in $450, 000 damage in southeastern Missouri on April 18.

At the end of April 1953, the mountain snowpack in the far West was generally above normal in northern areas where snowfall was heavier than usual in March and April, but was below normal in most southern sections. In eastern areas last winter's snowfall was below nor-

mal, except slightly above along the Canadian Border.

Floods during 1953 were rather local. Heavy rains in the Pacific Northwest caused flooding in northwestern California and western Oregon in January and October that resulted in several million dollars damage. Spring floods occurred in March in New England ($12, 000, 000 damage), in May from eastern Texas to Georgia ($100, 000, 000 damage in Louisiana), in June in Montana, Minnesota, and Iowa ($50, 000, 000 in Iowa), in August in Minnesota and southeastern Texas, and in October in southern Florida ($9, 000, 000). (From the Weekly Weather and Crop Bulletin National Summary for week ending February 15, 1954).

The Maps on page 123 show the temperature and precipitation for the winter of 1952-53, spring, summer, and fall of 1953.

Table 1. Diseases reported in States where they had not been found or reported on a particular host until 1953.

Host Disease (Cause)	Where found	Remarks
CORN Crazy top (Cause unknown)	New York	Observed for the first time in New York State on September 18, 1953. About 50 percent of the plants were found diseased in a five-acre field of corn growing in Limestone, Cattaraugus County. (PDR 38: 370)
WHEAT Glume blotch (*Septoria nodorum*)	Florida	Has been found effecting wheat extensively in the Southeastern Coastal Plain. This is the first observation of this fungus in Florida. (PDR 37: 310)
ARRHENATHERUM ELATIUS Eyespot (*Selenophoma donacis* var. *stomaticola*)	Washington	(PDR 38: 277)
CRABGRASS (DIGITARIA (ISCHAEMUM and D. SANGUINALIS) Rust (*Puccinia oahuensis*)	Louisiana	Apparently the first record of this fungus in Louisiana. Found in Sept. 1953 on *D. ischaemum*. (PDR 38: 120)
JOHNSON GRASS (SORGHUM HALEPENSE) *Sclerospora macrospora*	Louisiana	Grasses growing in the vicinity of infected sugarcane were examined for the disease. Findings indicated that Johnson grass is susceptible to attacks by the organism causing the Sclerospora disease of sugarcane. (PDR 37: 446)
APPLE Black pox (*Helminthosporium papulosum*)	Georgia	Found in Rabun and Fannin Counties. (PDR 37: 446)
CITRUS spp. Exocortis (Bud-transmissible virus)	Florida	Scaling of trifoliate butts was first reported in Fla. during the summer of 1952. Experiences of growers with losses from exocortis suggest

Table 1. (Continued)

Host Disease (Cause)	Where found	Remarks
Citrus spp. (continued)	Florida	that in Fla. trifoliate orange should not be resorted to except on a limited or experimental basis until more is known about the occurrence of the trouble in the citrus varieties of the State. (PDR 38: 12)
PEACH		
Wart (Virus)	New Mexico	Found during the late summer of 1952 in San Juan County. The disease was introduced into the County on Candoka nursery stock. Apparently no vector of the virus was present in this area. (PDR 38: 329)
Western X-disease (Virus)	Arizona	First experimental evidence confirming the existence of the disease in Ariz. In 1952 defoliated Elberta peach trees in an orchard in the Oak Creek Canyon area were found to be infected. (PDR 37: 508)
SWEET CHERRY (PRUNUS AVIUM)		
Verticillium wilt (_V. albo-atrum_)	California	During the 1952 and 1953 seasons symptoms of Verticillium wilt were observed in sweet cherry varieties growing in the Davis, Santa Clara and Stockton areas in California. (PDR 38: 438)
PECAN		
Articularia quercina	Oklahoma	The fungus was found in the Stillwater area in 1951, 1952 and 1953.
Microstroma juglandis var. _robustum_	Oklahoma	In May 1953, a catkin blight was found throughout the east-central pecan-growing area of Okla., occurring with varying intensity on all important pecan varieties and on many native pecans. (PDR 37: 511)

Table 2. Diseases found or reported in this country for the first time in 1953= *; diseases found on new hosts=**.

Host Disease (Cause)	Where found	Remarks
ALFALFA		
Root rot** Phytophthora sp.	California	In 1952 an undescribed root rot of alfalfa was observed in four counties of Calif. A Phytophthora sp. was isolated from diseased plants. The fungus was tentatively identified as P. cryptogea. (Phytopath. 43: 586)
BIG TREFOIL (LOTUS ULIGINOSUS)		
Southern blight** (Sclerotium rolfsii)	Georgia	First recognized as part of the big trefoil blight complex at Tifton in July 1953. This fungus attacks leaves and stems where free moisture is present during hot humid weather. (PDR 37: 521)
BIRDSFOOT TREFOIL (LOTUS CORNICULATUS)		
Stemphylium loti n. sp.	New York	Found in Northeastern U. S. in 1951. In the New York survey in 1952 it was found in all fields examined. No highly resistant plants were found. (Phytopath. 43: 577)
GRASSES		
Blast (Spermospora subulata) Leaf rust (Puccinia poae-sudeticae) Leaf streak (Scolecotrichum graminis) Scald (Rhynchosporium orthosporum) (R. secalis) Stripe rust (Puccinia glumarum)	Washington	Grass diseases observed in 1953 on new hosts in the Pullman Unit of the Soil Conservation Nurseries located at Pullman, Washington. (PDR 38: 277)
Dwarf bunt (Tilletia caries)	Oregon	New grass host records and life history observations of dwarf bunt in eastern Oregon. (PDR 38: 345).
CITRUS		
New virus disease	California	Induces vein swelling and enations on the lower leaf surface. Symptoms most pronounced on sour orange and Mexican lime. This

Table 2. (Continued)

Host Disease (Cause)	Where found	Remarks
(Citrus continued)		new virus is distinct from quick decline and is transmitted by at least one species of aphis. (Calif. Citrogr. 38: 180)
FIG Walnut branch wilt** (Hendersonula toruloidea)	California	Reported on fig about 20 miles from the severely damaged walnuts in Fresno County. (PDR 38: 238)
PEACH Fruit rot (Diplodina persicae n. sp.)	Louisiana	All varieties of peaches tested were found to be susceptible when inoculated under artificial conditions. Southland and Burbank Early Elberta were the most susceptible whereas Sunhigh was the least susceptible. (Phytopath. 44: 134)
STRAWBERRY Dematophora root and crown rot** (Rosellinia necatrix)	California	Observed in a planting of the Shasta variety in Santa Cruz County on land land recently cleared of old apple trees. (PDR 38: 72)
STRAWBERRY (FRAGARIA CHILOENSIS var. ANANASSA) Buckeye rot** (Phytophthora parasitica)	Tennessee	The fungus was found causing rot of several late appearing berries of the Aberdeen variety on July 19. (PDR 37: 527)
CARNATION (DIANTHUS CARYOPHYLLUS) Pimple (Xanthomonas oryzae new. var.)	Colorado	Isolated from pimple-like spots on leaves and stems. The bacterium has been transmitted to two carnation vars. and to D. barbatus. (PDR 37: 634)
CASTORBEAN (RICINUS COMMUNIS) Bacterial leaf spot* (Xanthomonas ricinicola)	Maryland Oklahoma Texas	This disease, new to the United States, was observed in commercial fields in Oklahoma and Texas in 1950, 1951, and 1952, and in varietal yield test plots in Mary-

Table 2. (Continued)

Host Disease (Cause)	Where found	Remarks
Castorbean continued)		land and Texas in 1952. The disease is believed to be widespread throughout the castor oil producing areas of the southern Great Plains. (PDR 37: 477)
CHRYSANTHEMUM MORIFOLIUM Bacterial blight Erwinia chrysanthemi	Massachusetts Florida North Carolina Ohio Connecticut Pennsylvania	Reports and specimens of this disease were received in 1951 and 1952; a hitherto unreported disease of greenhouse chrysanthemums. (Phytopath. 43: 522)
COCKSCOMB (CELOSIA ARGENTEA var. CRISTATA) Damping off** (Phytophthora parasitica)	Tennessee	Damping-off of a cockscomb plant about one foot in height was found to be due to the buckeye rot fungus. (PDR 37: 527)
JUNIPER MISTLETOE PHORADENDRON JUNIPERINUM) Rust** (Uredo phoradendri)	New Mexico	Collection made January 1953. The rust was not common at this location in the Sandia Mountains near Albuquerque. (PDR 37: 258)
LAMBSQUARTERS GOOSEFOOT (CHENOPODIUM ALBUM) Potato calico** (Virus)	Maine	Found in plants growing with infected potatoes in a short row in 1953. (PDR 38: 370)
LILY (LILIUM REGALE) Buckeye rot** (Phytophthora parasitica)	Tennessee	Observed early in July, as a top rot, causing collapse. Bulbs finally rotted completely. (PDR 37: 527)
PHILODENDRON CORDATUM Sclerotium rolfsii**	California	Found on P. cordatum grown under glass in southern California. (PDR 38: 530)

Table 2. (Continued)

Host Disease (Cause)	Where found	Remarks
TOBACCO "False broomrape" (Cause undet.)	Kentucky	New disease found in 1951 on the roots of burley tobacco. In 1952 diagnosed as broomrape; however, the "broomrape" did not get above ground. This summer a few leaves had gotten above ground and turned green. The trouble has been reported from nine counties. (PDR 37: 538)
	Florida	Appeared in Alachua County, Florida in 1951 and again in 1952. Descriptive details follow those given concerning the trouble in Kentucky. (PDR 37; 131)
Leaf curl* (?virus)	Kentucky	Identical in appearance with that found in India. Disease is graft-transmitted, and has been found in seven counties. (PDR 37: 538)
DOUGLAS FIR (PSEUDOTSUGA TAXIFOLIA) Lumber staining *Endoconidiophora coerulescens* f. *douglasii* n. form	Central Rocky Mountain	Apparently confined to Douglas fir, covers the sapwood with a black surface growth of mycelium and stains the wood below it light to dark gray. (Mycologia 45: 579)
FAN PALM (WASHINGTON FILIFERA) Phytophthora trunk rot** (Tentatively identified as *P. parasitica*)	California	A new disease of native fan palm has been found on numerous trees in yard plantings at Palm Springs. Leaves die rapidly and the trunks are almost completely rotted. (Phytopath. 43: 469)
QUERCUS AGRIFOLIA Q. CHRYSOLEPIS Oak wilt** (*Endoconidiophora fagacearum*)	Illinois	Incubation periods of 20 to 28 days were required when inoculations were made by injection of conidia with a hypodermic syringe at the base of the new growth. (PDR 37: 527)

Table 2. (Continued)

Host Disease (Cause)	Where found	Remarks
QUERCUS ILICIFOLIA Oak wilt (Endoconidiophora fagacearum)	Pennsylvania	The infected tree was found in Bedford County. This discovery increases the number of species of oak found infected in nature in the State to eight. (PDR 37: 567)
SALT-CEDAR (TAMARIX PENTANDRA) Bacterial parasite	Arizona New Mexico Texas	The first bacterial parasite to be reported for tamarisks. Remarkably resistant to heat. Salt-cedar is a most obnoxious weed. Natural enemies would be desirable. (PDR 37: 524)
CABBAGE Autogenous necrosis**	Wisconsin	This hitherto unreported disease of cabbage was described. It was found in certain inbred lines of cabbage. The disease appeared after midseason under Wisconsin conditions. (Phytopath. 43: 415)
LETTUCE Leaf spot (Stemphylium botryosum f. lactucum, forma nova)	California	Has been observed for 20 years in the Colma vegetable-growing district of San Mateo County. The pathogen is the imperfect stage of Pleospora herbarum f. lactucum, forma nova, pathogenic on and causing a leaf spot disease of lettuce (Phytopath. 44: 175)
LETTUCE Strain of tobacco-ringspot virus	California	In October 1953, a hitherto unreported disease of lettuce was observed in the Salinas Valley in a 15-acre field of the Great Lakes Variety. (PDR 38: 150)
PEPPER CAPSICUM FRUTESCENS Leaf disease ("velvet spot") (Cercospora unamunoi)	Florida Texas California	Colonies of C. unamunoi were found parasitized in some areas by Botrytis yuae sp. nov. (Phytopath. 44: 233)

Table 2. (Continued)

Host Disease (Cause)	Where found	Remarks
TOMATO New virus disease (V-52-1)	Illinois	A virus (designated V-52-1) with some properties of common tobacco mosaic virus (TMV) has been identified as the cause of a new virus disease. Symptoms were described (Phytopath. 43: 480)
WATERMELON Watermelon mosaic virus (Marmor citrulli sp. nov.) Yellow watermelon mosaic virus (Marmor citrulli flavidanum var. nov.)	Florida	Both strains were transmitted by Myzus persicae. Host range: all tested cucurbits except Momordica charantia. (Phytopath. 44: 198)

DISEASES OF CEREAL CROPS

Futrell and Atkins reported diseases of small grains in Texas in 1953. The crop season was one of great extremes resulting in a near failure over the majority of the wheat-producing areas, with a bumper crop in other areas. Extreme drought has persisted in the major-wheat-producing area of West Texas for three years. Total wheat production in Texas in 1953 was less than half the ten-year average. By contrast conditions were, for the most part, favorable for oats, which are largely grown in Central Texas, and the estimated crop was considerably above the ten-year average. (PDR 38: 167).

E. D. Hansing summarized 1953 tests of new compared with older fungicides for the control of cereal smuts (Tilletia spp., Ustilago avenae, U. kolleri and Sphacelotheca sorghi) in Kansas in 1953. (PDR 38: 389).

AVENA SATIVA. OATS: Moseman and others reported the reaction of winter oat varieties and selections to soil-borne viruses in southeastern United States. (PDR 37: 226-229). An improved method of inoculating seed of oats and barley with smut was reported by W. Popp and W. J. Cherewick. (Phytopath 43: 697). Earhart and Moseman reported that new oat introductions carrying resistance both to the prevalent races of rust and to soil-borne mosaic viruses should help plant breeders in developing varieties for the Southeast. (PDR 37: 597).

Erysiphe graminis, powdery mildew. Schafer and Caldwell reported that powdery mildew could not be found on winter oats early in the season in Indiana, but by mid-June it was abundant in the Lafayette nursery although on oats it developed less vigorously than on either wheat or barley. This was believed to be the first report of powdery mildew on oats in the field in Indiana. (PDR 37: 569).

Helminthosporium victoriae, blight. N. C. Finkner reported inheritance of susceptibility to Helminthosporium victoriae in crosses involving Victoria and other crown rust (Puccinia coronata) resistant oat varieties. No indication of linkage was detected between the Victoria type of crown rust resistance and susceptibility to H. victoriae. (Agron. Jour. 45: 404).

Puccinia graminis, stem rust, was present in all winter-sown fields examined in southern Illinois. Prevalence ranged from 21 to 64 percent (average 51.4 percent) and severity averaged 0.05 percent. (G. H. Boewe, PDR 37: 411).

S. S. Ivanoff described spikelet-drop, cause unknown, of oats in Mississippi. He stated that it was difficult to state whether this "spikelet drop" is a new disease, or a little-observed symptom of an already known disease. (PDR 38: 275).

HORDEUM VULGARE. BARLEY: Erysiphe graminis var. hordei, powdery mildew. J. G. Moseman reported reaction of barley varieties and selections to physiological races of powdery mildew. (PDR 38: 163).

Viruses. H. H. McKinney summarized the results of studies to facilitate the rapid detection of seed-borne virus in Glacier barley. (PDR 38: 152).

LINUM USITATISSIMUM. FLAX: H. H. Flor reported on the epidemiology of flax rust, Melampsora lini, in the North Central States. Flax rust differs from the rusts of cereals in a number of important respects that affect its epidemiology. (Phytopath. 43: 624).

SECALE CEREALE. RYE: Puccinia rubigo-vera secalis, leaf rust, was present on rye examined in Illinois as far north as the central part of the State. In the southern part it was present on all the plants and averaged 20 percent severity on all plants. (G. H. Boewe, PDR 37: 411).

SORGHUM spp. SORGHUM: Seventeen fungicidal chemicals were tested on smut-infested seed of Sharon kafir and Leoti sorgo with regard to their effect on emergence in steamed and in infested soils, on field stands, and on control of covered kernel smut. (Leukel and Webster, PDR 37: 585).

Results of the 1953 sorghum seed-treatment tests for covered-kernel smut (Sphacelotheca sorghi) control in Colorado were reported by R. H. Porter. (PDR 38: 88).

SORGHUM HALEPENSE. JOHNSON GRASS: In Louisiana L. L. Farrar reported a downy mildew (Sclerospora ? macrospora) on Johnson grass, and discussed its possible relationship with downy mildew on sugarcane. (PDR 37: 446).

TRITICUM AESTIVUM. WHEAT: Tests reported by Alvin Overland and W. L. Nelson, from Washington, indicated that copper carbonate slurry is injurious to wheat seed, particularly under low temperature conditions. With respect to varieties, the winter wheats were more adversely affected by the copper carbonate slurry treatment than the spring wheats. This was especially true at 3° C. (PDR 38: 25).

Anguina tritici, wheat nematode. J. M. Raeder proved that the wheat nematode can remain viable and active over a period of 14 years of dormancy. (PDR 38: 268).

Erysiphe graminis, powdery mildew, according to Schafer and Caldwell, developed abundantly and early on winter wheat throughout Indiana in 1953. (PDR 37: 569).

Helminthosporium sativum, root rot. The dryland root rot complex of winter wheat was widespread in eastern New Mexico in 1953, according to C. H. Hsi, who discussed the factors that favored its occurrence. H. sativum was most frequently isolated from the diseased roots. (PDR 38: 270).

H. tritici-vulgaris, leaf spot, was present on all plants and very severe on some varieties in southern Illinois, according to G. H. Boewe. (PDR 37: 411).

Puccinia graminis tritici, stem rust. Tests demonstrated that certain of the sulfa drugs will control wheat stem rust when applied as a post-infection spray at a rate as low as 5 lbs. per acre. This control can be counteracted by para-amino benzoic acid and folic acid, allowing the rust to recover. These acids apparently are vitamins in the metabolism of P. graminis tritici. (Phytopath. 43: 659).

Puccinia rubigo-vera tritici, leaf rust, was conspicuous by its absence in southern Illinois, according to G. H. Boewe. The first leaf rust (one pustule) was observed in Pulaski County on April 30. The extremely dry weather last summer and fall, the cool weather in April and most of May, and the use of resistant varieties may account for the light leaf rust development as moisture was plentiful in the spring. (PDR 37: 411).

J. E. Livingston reported that 179 chemicals were tested to determine their value as chemotherapeutic agents in control of P. rubigo-vera on wheat. Calcium sulfamate was the most effective chemical for stopping the development of pustules of P. rubigo-vera and P. graminis tritici in the tissue of wheat leaves in field trials. (Phytopath. 43: 496).

Septoria nodorum, glume blotch. R. W. Earhart reported reaction of wheat varieties to Septoria nodorum in Florida. (PDR 37: 436). This fungus infected every wheat planting in the south-eastern Coastal Plain, Florida, during the 1953 growing season. Leaves and leaf sheaths were primarily infected but only minor damage was observed on the glumes.

Tilletia brevifaciens, dwarf bunt. The results of preliminary trials conducted at Ithaca, New York indicated that a straw covering during the winter was favorable to the development of dwarf bunt of winter wheat and that inoculum applied to the soil was consistently more effective under the prevailing conditions of light snowfall and repeated thawing than that applied directly to the seed. (L. J. Tyler and N. F. Jensen. PDR 37: 465).

T. caries, bunt. Holton and Woo reported results of tests with several standard seed-treatment fungicides and experimental chemical materials to determine their relative effectiveness in controlling seed-borne common bunt of winter and spring wheat at Pullman, Washington in 1952-1953. (PDR 37: 583).

Typhula spp. and Fusarium nivale, snow mold. Roderick Sprague reported results of tests with fungicides for control of this disease. (PDR 37: 360).

Wayne M. Bever reported that eight races of Ustilago tritici were isolated from 56 loose-smut collections made in 1947. A total of 19 races have been described. Race 1 is still the most prevalent. The results indicated that new varieties of wheat, constituting different germ plasm, shift the prevalence of the different physiologic races of U. tritici. Kawvale was resistant to all races and should be an excellent parent in breeding for resistance to loose smut. (Phytopath. 43: 681).

Mosaic Viruses.

Recognition of widespread occurrence of the soil-borne wheat mosaic viruses in Virginia was associated with the recent general use of susceptible varieties, according to C. W. Roane and others. (PDR 38: 14). J. G. Moseman and others reported reaction of wheat varieties and selections to the soil-borne viruses in the Southeast. (PDR 38: 19). Yield comparisons between wheat varieties grown on mosaic-virus-infested and noninfested soil in Illinois was reported by Beaver and Pendleton. (PDR 38: 266).

A virus disease transmitted by the leafhopper Endria inimica was found on winter and late spring wheat in South Dakota in 1950-51, according to J. T. Slykhuis. "Striate mosaic" is the name proposed for this disease because the symptoms include fine chlorotic streaks along the

veins of the leaves. Nymphs and adults of this leafhopper function as vectors. Some individual leafhoppers transmit the virus only once while others transmitted it many times before they died. The virus overwinters on winter wheat. Striate mosaic on wheat in South Dakota has several characteristics in common with two virus diseases reported on wheat and oats in the U.S.S.R. (Phytopath. 43: 537).

ZEA MAYS. CORN: Bacterium stewartii, Stewart's disease or bacterial wilt, of corn was predicted to occur over most of Illinois and be more destructive much farther north in the State than it was in the summer of 1952. Since this was the warmest winter in Illinois since that of 1931-32, damage and loss from the disease was expected to be the heaviest it had been in the past 21 years. This forecast, the fifth for the State, was based on the close relationship that appears to exist between the amount of disease which develops during the summer and the temperature of the preceding winter. (G. H. Boewe, PDR 37: 311). Stewart's disease was killing 0.3 percent of the plants in an early planted field of corn in Alexander County, Illinois on May 28. This is the earliest record of the occurrence of the disease on field corn. The corn was about knee high. (G. H. Boewe. PDR 37: 411). In a review of the corn disease situation in Illinois in 1953, Benjamin Koehler stated that a considerable number of sweet-corn fields were ruined by Stewarts' disease during June, even though wilt resistant hybrids had been used for the most part. In view of the mild temperatures of the preceding winter, total damage was not as great as had been anticipated. For the State as a whole, damage to yield was estimated at about 2.8 percent, the highest since 1938. (Univ. Ill. Agr. Expt. Sta. Bull. 571: 10).

Fusarium moniliforme, ear rots caused concern in some parts of Illinois, but on the whole damage was lower than it had been for several years, according to Koehler (Univ. of Ill. Agr. Expt. Sta. Bull. 571: 12).

Helminthosporium turcicum, northern leaf blight. According to Koehler, in Illinois only traces of this leaf blight were found in some test fields and none in others. (Univ. of Ill. Agr. Expt. Sta. Bull. 571: 12).

H. turcicum and Puccinia sorghi, leaf blight and rust. In inaugurating a breeding program for resistance to these two diseases, A. L. Hooker reported that it seemed desirable to obtain data on the relative efficacy of various methods of inducing field infections in central Iowa with the two pathogens. He has furnished a brief description of them and a summary of the pertinent results. (PDR 38: 173).

Macrophomina phaseoli, charcoal rot, was more abundant than it had been for many years in the hot dry areas of Illinois, which included most of the lower two-thirds of the State. (Univ. of Ill. Agr. Expt. Sta. Bull. 571: 12).

P. A. Young reported that meadow nematodes, (Pratylenchus) had been observed to be the cause of considerable damage to corn in east Texas. Early cultivation to aerate cold wet soil around the roots of corn seedlings probably will minimize damage from the nematodes. (PDR 37: 599). J. M. Good and others reported results of experiments to determine the effect of crop rotation on populations of meadow nematodes (P. leiocephalus) in Florida. The lowest infestation following corn occurred in the two-year rotation with intermediate numbers occurring where corn, the most susceptible plant, was grown two years and peanuts one. (PDR 38: 178).

Ustilago maydis, smut, was considerably more prevalent than usual in Illinois. For the State as a whole, smut was estimated to have cut yield 1.7 percent. This is the highest loss since 1940 when damage was 4 percent. (Koehler, Univ. Ill. Agr. Expt. Sta. Bull. 571: 12).

DISEASES OF FORAGE AND COVER CROPS

Estimated crop losses due to some diseases of forage legumes and grasses in New York, in 1953 were reported by Daniel A. Roberts and others. (PDR 38: 30). Experimental studies of the host ranges of Pratylenchus vulnus and P. penetrans were reported by Harold J. Jensen. Trials designed to discover cover crops non-susceptible to P. penetrans involved 33 different kinds of plants. All of the plants used in these trials were found to be hosts for this nematode. The major differences in the experimental host ranges of the two species presented in these data were that P. penetrans was attracted to the Gramineae while P. vulnus apparently avoids them. (PDR 37: 384).

BROMUS MARGINATUS. BROME GRASS: Ustilago bullata, head smut. Meiners and Dietz reported seed treatment trials for control of head smut in 1953. On the basis of two years' results which were nearly identical, Ceresan M and Panogen were recommended for treatment of mountain brome seed to control head smut. Ceresan M may be used either as a dust or a

slurry, and Panogen may be used in concentrated or dilute form. (PDR 37: 595).

DACTYLIS GLOMERATA. ORCHARD GRASS: John R. Hardison and H. J. Jensen reported a nematode (Anguina) seed-gall disease of orchard grass in Oregon. Three malformed panicles bearing nematode galls in place of seeds were found in May 1947, on the Oregon Agricultural Experiment Station farm at Granger. (PDR 37: 388).

POA spp. BLUEGRASS: Puccinia graminis, stem rust. In a lawn at Manhattan, Kansas Merion bluegrass was found to be heavily infected on October 22, 1953. Because of the increasing interest in Merion bluegrass, it seemed desirable to record its susceptibility to stem rust. (Rogerson and King, PDR 38: 57).

Puccinia rubigo-vera, leaf rust, was reported in August 1953 in a lawn of Merion bluegrass in Lincoln, Nebraska. It had been seeded in the early spring of 1953. Weather prior to the outbreak of the rust consisted of fairly cool nights with heavy dews, and warm, sunny days with relatively high humidity. This combination of conditions coupled with frequent watering apparently favored the development of this outbreak of leaf rust. (W. W. Ray, PDR 37: 578).

Cereal yellow dwarf virus was shown by studies at the University of California to have a wide host range in the grass family. Severe epiphytotics of the disease are promoted by a warm, continuously wet winter, favoring rank growth of wild grasses and rapid reproduction of the aphid vectors. Eventual control depends on the development of resistant strains. (Oswald and Houston, Phytopath. 43: 309).

LEGUMES

E. W. Hanson gave an account of the prevalence and severity of diseases of red clover, Ladino clover, lucerne, and sweet clover (Melilotus spp.) in Wisconsin during the years 1946 to 1952 inclusive, based on State-wide surveys. (PDR 37: 467).

Belonolaimus gracilis, sting nematode. Holdeman and Graham discussed the effects of various plants on the maintenance and increase of the sting nematode populations. Field observations revealed that soybean and cowpea increased the severity of the trouble on the next crop. Crab grass was largely responsible for maintaining an infestation. (PDR 37: 497).

GLYCINE MAX. SOYBEAN: John Dunleavy reported occurrence of soybean diseases in Iowa in 1953. (PDR 38: 89).

Pellicularia filamentosa, Rhizoctonia aerial blight, for three consecutive years, 1950-52, was observed in soybean nurseries and nearby test fields at Baton Rouge, Louisiana. The disease first appeared during the summer and persisted during the fall. In 1951 and 1952 microsclerotia were produced abundantly under field conditions. Varietal differences in susceptibility were observed. (Phytopath. 44: 215).

Peronospora manshurica, downy mildew. S. G. Lehman reported that the results of greenhouse tests in the spring of 1952 demonstrated the existence in North Carolina of another physiologic race, designated as race 4, of P. manshurica, in addition to the three previously known. (Phytopath. 43: 292).

LOTUS ULIGINOSUS, BIG TREFOIL: During 1952 and 1953, systemic observations were made on diseases of big trefoil in Georgia. Diseases observed were: summer blight (Rhizoctonia solani), blackpatch (blackpatch fungus), anthracnose (Colletotrichum truncatum), and southern blight (Sclerotium rolfsii). The first three diseases had been reported on big trefoil, but southern blight had not been reported previously. (Homer D. Wells, PDR 37: 521).

MEDICAGO SATIVA. ALFALFA: The Armstrongs reported that cross-inoculation experiments demonstrated that wilt-producing Fusaria from cotton and cassia as well as alfalfa will infect alfalfa. (PDR 38: 221).

Peronospora trifoliorum, downy mildew, An unusual epidemic was present in the southern part of Illinois. Approximately 50 percent of the plants were diseased. In about 5 percent of the plants, all the tip leaves were diseased and severely dwarfed and deformed. (G. H. Boewe, PDR 37: 412).

Etiology and epidemiology of the leaf spot of alfalfa caused by Stemphylium botryosum were studied in the field and greenhouse, and the perfect stage of the organism was identified as Pseudoplea briosiana. Relative humidity of 100 percent for at least 12 hours was essential for initial infection, and temperatures from 16° to 25° C were most conducive to further development of the disease. When these conditions occur the disease can be epidemic in Minnesota.

There are pathogenic races of the pathogen. (Kernkamp and Nelson, Phytopath. 43: 477).

Lucerne witches' broom virus spreads more rapidly in small, thin stands than in larger, dense plantings, according to Menzies (Phytopath. 32: 564). From observations in the Methow Valley of Washington it appeared that the normally slow spread of infection into new plantings may be effectively prevented by the area wide removal of old, diseased fields, followed by reseeding and the maintenance of dense, productive stands through rational cultural practices.

TRIFOLIUM PRATENSE. RED CLOVER: Sclerotinia trifoliorum, crown rot. A technique for field inoculation of red clover with S. trifoliorum was described by J. H. Graham and R. G. Hanson. (PDR 37: 518).

TRIFOLIUM REPENS. WHITE CLOVER: A cyst-forming nematode identified as Heterodera schachtii var. trifolii has been found widely distributed in Illinois in association with T. repens in old pastures, lawns, and roadsides. It probably is not a recent introduction. (Phytopath. 43: 603).

Houston and Oswald reported the mosaic virus disease complex of Ladino clover (Trifolium repens var. Ladino) in California. (Phytopath. 43: 271).

DISEASES OF FRUIT CROPS

J. M. Ogawa and others reported the results of a survey for brown rot (Monilinia spp.) of stone fruits in California. No major change had occurred in the distribution of the brown-rot organisms in California since the previous survey in 1939. M. fructicola was found in the additional counties of Madera, Napa, and Solano, and M. laxa in San Diego County. M. fructicola is important as a cause of fruit rot of peach, whereas M. laxa is primarily a blossom-and twig-blighting organism on almonds and apricots. Direct infections of young apricot shoots by M. laxa were found extensively in California for the first time in 1953. (PDR 38: 254).

CITRUS spp. CITRUS: Erdman West and others reported that brown rot of citrus fruit on the tree, caused by Phytophthora spp., was found in three different citrus-growing areas in Florida in October 1953. The organism is probably P. parasitica. This fungus has been known for years in Florida as the cause of foot rot of trees and decay of fruits on the ground but had previously not been observed to attack fruit on the tree. In California such infection has been known for many years. (PDR 38: 120).

Crinkle-scurf. Results of transmission trials with crinkle-scurf of citrus in Florida indicate that the disorder does not behave like an infectious disease. However, symptoms are propagable in shoots from affected buds. Prospective bud sources should be examined for crinkle-scurf and trees found affected should be avoided in the interest of maintaining varieties true to type. (L. C. Knorr, PDR 37: 503).

Scaly bark. According to Knorr and Thompson scaly bark, formerly widespread, is now to be found only in a few neglected groves on the East Coast of Florida. On the basis of spray trials it was concluded that Florida scaly bark can be economically, thoroughly and safely controlled by a single yearly spraying with wettable sulfur. Results support the hypothesis that mites (Brevipalpus) are involved in the development of the disease. (PDR 38: 143).

Spreading decline. H. W. Ford reported the effect of spreading decline disease on the distribution of feeder roots of orange and grapefruit trees on rough lemon rootstock in Florida (Proc. Amer. Soc. Hort. Sci. 61: 68). Ford also reported changes in rate of respiration and catalase activity associated with spreading decline of citrus trees (Proc. Amer. Soc. Hort. Sci. 61: 73). Evidence reported by R. F. Suit and E. P. DuCharme indicated that the burrowing nematode (Radopholus similis) is the cause of the spreading decline disease of citrus trees in Florida. Several other parasitic nematodes were found associated with citrus feeder roots. Aphelenchus avenae apparently is not a factor in spreading decline since it was found also in healthy groves free from disease. This is the first time that this nematode has been reported as associated with citrus roots in the United States. Hoplolaimus coronatus, P. pratensis, Trichodorus sp., Xiphinema americanum, and Hemicycliophora sp. probably are not related to spreading decline, although these nematodes have been found associated with citrus feeder roots. The type and extent of injury they cause has not as yet been determined. (PDR 37: 379).

Stem pitting, a symptom of quick decline, was first observed in California citrus orchards in 1952. The appearance in the State was anticipated. Stem pitting and tristeza in South Africa and Brazil were shown to be interrelated, probably symptom expressions of the same virus complex. (Bitters, W. P., Calif. Agriculture 7 (1): 9, 14. Jan. 1953).

Winter Haven decline, a serious malady, has caused a considerable loss to citrus in the Winter Garden district of Texas. The disease has been observed only on trees ten years old or older and on a number of different rootstocks. Of the 41 root and soil samples taken from the root-zone area of affected and adjacent healthy trees 38 yielded Pythium ultimum. Since the fungus appeared to be active in this area in both winter and summer it may be partly responsible for the disease in combination with shallow soil and recurring periods of excessive and deficient soil moisture. (Bailey Sleeth, PDR 37: 425).

FRAGARIA spp. STRAWBERRY: Aphelenchoides fragariae, strawberry dwarf, was reported by W. L. Yount, in a 2-acre area of strawberries near Stevens, Pennsylvania. Plants of eight varieties were found to be affected by the disease. (PDR 37: 429).

Botrytis cinerea, gray mold. In Illinois according to Dwight Powell, captan gave good control of gray mold rot on strawberries and increased yield as well. (PDR 38: 209).

Phytophthora fragariae, red stele. G. F. Waldo reported sources of red stele root disease resistance in breeding strawberries in Oregon. (PDR 37: 236).

Viruses:

J. P. Fulton reported results of studies confirming Posnette's report that the virus content of infected strawberry plants can be modified by heat and that in some cases the plants can be rendered virus-free. It seems logical to assume that a method can be developed which will consistently yield virus-free strawberry plants. (PDR 38: 147). Miller and Darrow reported that two wild roses (R. nutkana and R. rubiginosa) have been found to be hosts for the common strawberry aphid (Capitophorus fragaefolii). Collections of the aphids were made during the summer and fall of 1953 from wild roses growing along the highways and fence rows in six different locations near Corvallis, Oregon and one in Washington. (PDR 38: 70).

Strawberry latent virus. This virus has been found to occur in the East Malling clone of F. vesca and in plants of F. bracteata originating in California. In combination with a second virus a more severe disease resulted than would be caused by either virus alone. The virus from F. vesca was designated strain A, and that from F. bracteata as strain B, of the strawberry latent virus. The virus has been transmitted only by grafting. (Norman W. Frazier, PDR 37: 606).

According to P. W. Miller, the hot-water treatment of virus-infected strawberries is not a commercial method of control, but may prove to be a possible means of obtaining virus-free clones of certain varieties now completely infected. (PDR 37: 609).

MALUS SYLVESTRIS. APPLE: Copper 8-quinolinolate (Bioquin 1), according to Dwight Powell, was compared with a number of commercial fungicides in field tests on apples and pears. It was excellent against bitter rot (Glomerella cingulata), sooty blotch (Gloeodes pomigena), and fly speck (Leptothyrium pomi); good against apple scab (Venturia inaequalis), apple blotch (Phyllosticta solitaria) and leaf spot (Fabraea maculata); and fair in the control of cedar rust (Gymnosporangium juniperi-virginianae). It was not satisfactory in controlling fire blight (Erwinia amylovora). Bioquin 1 was not phytotoxic at concentrations suitable for disease control. (PDR 38: 76).

Erwinia amylovora, fireblight. At the Ohio Agricultural Experiment Station, Wooster, experiments for the control of apple fireblight were carried out in 1952 and 1953. Three to five sprays of streptomycin or Terramycin on successive days were effective in preventing infection on young Jonathan apple trees in the greenhouse when twigs were needle-inoculated on the day of the last spray. Trees inoculated seven days after the last spray, however, developed 100 percent infection. Trees given three applications of streptomycin at 60 and 120 p.p.m. with 2 oz. Triton B-1956 were in excellent condition 17 days after inoculation with only a few infections, the unsprayed being severely blighted. (Winter and Young, PDR 37: 463).

Podosphaera leucotricha, powdery mildew. According to Roderick Sprague, 1953 is the fifth year of a series of spray trials at Wenatchee, Washington. In studying results of spraying attention should be given to the amount of overwintered mildew in a block. In their plots it varied appreciably. Relatively effective sprays included Polysulfide Compound, lime-sulfur, and Karathane. There was much less mildew etching on the fruit of sprayed trees than in the unsprayed checks. (PDR 37: 601).

Venturia inaequalis, scab. In Connecticut during 1953, an early warm, wet spell caused the discharge of most of the ascospores of the apple scab fungus before the opening of the apple buds. Most scab development was from conidial infection. During the three or four years prior to 1953 unsprayed McIntosh trees were almost completely defoliated by scab. In 1953, however,

comparable trees, although about 50 percent infected, retained most of their foliage. (Saul Rich, PDR 37: 636).

The previously unrecognized conidial stage of Microthyriella rubi has been isolated from the flyspecks on apples from California and Virginia, according to R. D. Durbin and others. This dermatiaceous fungus, Zygophiala jamaicensis, originally described on banana and recently reported to cause greasy blotch of carnation, has a wide host range. (Phytopath. 43: 470).

In Rhode Island, Shutak and others reported the role of cutin in storage scald of apple, and the effect of mineral oil on storage scald. (Proc. Amer. Soc. Hort. Sci. 61: 228-236).

PERSEA AMERICANA. AVOCADO: Phytophthora cinnamomi, root rot. In California G. A. Zentmyer reported progress on avocado root rot research. Investigations on control under way at Riverside, in co-operation with the University of California and the Agricultural Extension Service, include a search for resistant stocks among collections made in swampy locations in Central America and Mexico, replanting infested soil with resistant crops, the compilation of the host list of the fungus, experiments on various soil treatments and amendments and on irrigation methods, investigation of the occurrence of the pathogen in indigenous soils, and a study of the biology of P. cinnamomi itself. (Calif. Citrogr. 38: 256).

Spreading decline. Citrus groves in Florida rendered unprofitable by spreading decline are frequently replaced with avocado trees. Investigation showed that the burrowing nematode, Radopholus similis, attacks avocado as well as citrus, in which it causes spreading decline. In addition to R. similis and Pratylenchus pratensis, Aphelenchus avenae, Criconemoides citri, Trichodorus sp. and various Dorylaimids were also found associated with avocado roots. (DuCharme and Suit, PDR 37: 427).

PRUNUS spp. CHERRY: The special care needed to prevent introduction of viruses in symptomless host carriers was emphasized in J. A. Milbrath's account of the "Eckelrader" disease in cherry importations from Europe. (PDR 38: 258).

PRUNUS PERSICA. PEACH: Peter A. Ark discussed some important sources of crown gall bacteria (Agrobacterium tumefaciens) in California, where crown gall is a serious problem in many peach, almond, and prune orchards. (PDR 38: 207).

Cladosporium carpophilum, scab, Incidence of peach scab was markedly reduced on whitewashed trees, in Georgia experiments, according to a report by KenKnight and Jones. (PDR 37: 509).

Clitocybe tabescens, root rot. Arthur S. Rhoads discussed the presence and reasons for the spread of Clitocybe root rot in peach orchards in South Carolina and Georgia. (PDR 38: 42).

Fusicoccum amygdali, large leaf spot and canker, according to Emil F. Guba has become prevalent in the North Atlantic region during the past ten years. The fungus winters over in the cankers and apparently in infected leaves. Successful control of the disease was obtained in southeastern Massachusetts. Orchards that were on the verge of being abandoned are being rehabilitated by fungicidal protection throughout the season, beginning with lime sulfur at delayed dormant. Protection of the trees with fungicide up to the middle of October is necessary. (PDR 37: 560).

Monilinia fructicola, brown rot. Tests of organic fungicides for brown rot control on peaches in South Carolina were reported by H. H. Foster. (Phytopath. 43: 290).

Xanthomonas pruni, bacterial spot. Small scale experiments in 1951-52 indicated that fall applications of copper sulfate, if applied at the proper time, would eliminate the source of primary infection for peach bacterial spot in the spring, but H. W. Anderson reported disappointing results secured in the 1953 season in Illinois. In none of the experiments was there any evidence of reduction of either spring canker development of primary infection on the foliage over that found in the unsprayed trees. (PDR 37: 493). Results of limited experiments reported by John C. Dunegan and others indicated that after injections of the antibiotic Terramycin into peach trees infection with bacterial spot was reduced and defoliation delayed. (PDR 37: 604).

Phony disease (virus). Lee M. Hutchins and others reported the transmission of phony disease virus from tops of certain affected peach and plum trees. (Phytopath. 43: 691).

Ring spot (virus). The peach ring spot virus did not seem to be present in the variety collection at the U. S. Horticultural Station, Fort Valley, Georgia, according to tests reported by Glenn KenKnight and Julian F. Jones. (PDR 37: 346).

PYRUS COMMUNIS. PEAR: Erwinia amylovora, fire blight. An epiphytotic of pear fire blight occurred in California during the spring of 1953, according to P. A. Ark. In a control trial on Bartlett trees bentonite dust containing 240 p. p. m. streptomycin base gave 83.8 percent control without fruit russeting when applied four times during March and April. A copper-dust-treated plot developed light to severe fruit russetting, whereas the streptomycin-treated trees produced russet-free fruit. (PDR 37: 404).

RUBUS spp. RASPBERRY: Erwinia amylovora f. sp. rubi, bacterial fire blight. Donald Folsom reported evidence indicating that inoculum carried by the raspberry cane maggot (Phorbia rubivora or Hylemyia rubivora or Pegomya rubivora) was responsible for new infections by the raspberry fire blight bacterium in Maine. (PDR 38: 338).

RUBUS spp. WILD BLACKBERRY: Elsinoe veneta, anthracnose. R. A. Jehle and others reported additional records of spot anthracnose in Maryland. (PDR 37: 372).

RUBUS IDAEUS. RED RASPBERRY: The technique employed for indexing red raspberry plants for viruses in Washington was described by Glenn A. Huber. This method of indexing both raspberry and strawberry plants has been in use during the past two seasons. (PDR 38: 68).

VACCINIUM AUSTRALE. BLUEBERRY: Pseudomonas sp. was shown to be the cause of a serious stem canker of blueberry which has been under observation in western Oregon during the past five years. The only canes affected are those produced the previous season. All the buds in the cankered area are killed and the stem may be girdled. Some hybrids proved to be highly resistant. (Stace-Smith and others. Phytopath. 43: 588).

VACCINIUM CORYMBOSUM. BLUEBERRY: Ringspot, a virus disease of the cultivated highbush blueberry in New Jersey, was described by Hutchinson and Varney. (PDR 37: 260).

Elsinoë ampelina, anthracnose. R. A. Jehle and others reported additional records of spot anthracnose in Maryland. (PDR 37: 372).

Pierce's disease (virus). Stoner reported that Pierce's disease virus infection was a cause of grape degeneration in Florida. Carneocephala flaviceps was a hitherto unrecorded vector. (Phytopath. 43: 293). Freitag and Frazier reported natural infectivity of leafhopper vectors of Pierce's disease virus of grape in California. (Phytopath. 44: 7).

DISEASES OF NUT CROPS

P. W. Miller reported on nut diseases in Oregon in 1953. (PDR 38: 80).

CARYA PECAN. PECAN: Cladosporium effusum, scab. J. R. Large reported the results of aeroplane spraying for pecan scab control at Monticello, Florida. (PDR 37: 266).

John R. Cole reported diseases causing partial or total losses to pecan trees or nuts in the Southeastern States where no control measures were employed. The most severe of all these was scab, Cladosporium effusum. The weather in 1953 favored the development and spread of the fungus, probably causing a loss of 5 to 10 million pounds of nuts on susceptible varieties. Cephalothecium roseum, pink rot, was present on many of the scabby nuts. Among other diseases of less economic importance was crown gall (Agrobacterium tumefaciens), which attacks the crown and lateral roots of the tree. Foliage diseases causing minor to serious damage to the pecan crops were downy spot (Mycosphaerella caryigena); peach leaf blotch (Mycosphaerella dendroides); powdery mildew (Microsphaera alni); brown leaf spot (Cercospora fusca). Where growers are spraying to control scab the same spray materials and applications will also control these foliage diseases. Rosette (zinc deficiency) and leaf scorch (cause unknown) were the most important nutritional diseases. (PDR 37: 510).

DISEASES OF ORNAMENTALS

Damping-off fungi, such as Rhizoctonia solani and Pythium ultimum, cause considerable damage to various nursery ornamentals when the plants are in the early seedling stages. Panogen (methyl-mercury-dicyan-diamide) showed considerable toxicity to damping-off

fungi such as the two mentioned, according to Ark and Sibray. (PDR 38: 204).

Kenneth F. Baker and others described a grafting failure of ornamental plants caused by Thielaviopsis basicola. Grafting failure caused by T. basicola appears not to have been previously reported. (PDR 37: 526).

Observations on natural infection of ornamental flowering plants with the curly-top virus (Ruga verrucosans) in southern New Mexico were summarized by Philip J. Leyendecker. (PDR 37: 552).

CAMELLIA spp. CAMELLIA: The transmission of leaf and flower variegation in camellias by grafting was reported by A. G. Plakidas. (Phytopath. 44: 14).

Baxter and Plakidas reported results of a study of dieback and canker of camellia caused by Glomerella cingulata. (Phytopath. 44: 129).

CHRYSANTHEMUM spp. CHRYSANTHEMUM: Brierley and Smith reported detection of Noordam's B virus of chrysanthemum in the United States (PDR 37: 280).

DIANTHUS spp. CARNATION: W. D. Thomas, Jr. reported a flower malformation of Hercules carnation caused by aster yellows virus in commercial greenhouses in the Denver and Colorado Springs areas, Colorado. (PDR 37: 284).

GLADIOLUS spp., GLADIOLUS: Both bacterial scab, Pseudomonas marginata, and fungus diseases of gladiolus corms can be controlled by certain fungicide-insecticide mixtures, according to Roy A Young, reporting investigations in Oregon. (PDR 38: 55).

Western aster yellows virus. Floyd F. Smith and Philip Brierley reported that inoculation with the western aster yellows virus reproduced symptoms of grassy top in gladiolus. (PDR 37: 547).

HEDERA HELIX. ENGLISH IVY: Sphaceloma hederae, English ivy scab. R. A. Jehle and others reported additional records for Maryland. (PDR 37: 372).

HELIANTHUS ANNUUS. SUNFLOWER: The culture of Erysiphe cichoracearum on sunflower crown gall (Agrobacterium tumefaciens) tissue was reported by J. M. Heim and G. A. Gries. (Phytopath. 43: 343).

C. E. Yarwood described a quick rubbing method for inoculation with viruses. (PDR 37: 501).

IRIS sp. IRIS: Topple disease. A previously unreported topple disease in the Wedgewood variety of Dutch iris has been observed on two occasions, according to Frank A. Haasis. At Babylon, Long Island, New York in December 1942 approximately 30 percent of the 50,000 Wedgewood plants growing in flats were affected with topple. At Castle Hayne, North Carolina in November 1952, 14 percent of the plants in flats in a greenhouse were affected. (PDR 37: 558).

LILIUM spp. LILY: Aphelenchoides fragariae, foliar nematode. According to Oregon tests reported by Jensen and Caveness control of foliar nematodes in Bellingham Hybrid lilies can be obtained with hot water-formaldehyde bulb treatment or with foliage spray of Systox. Control by these methods was achieved with no apparent injury to the lilies. (PDR 38: 181).

LOBULARIA MARITIMA. SWEET ALYSSUM: Association of various fungi with poor germination of the 1953-crop sweet alyssum seed was reported by Crosier and Heit. (PDR 38: 286).

NARCISSUS sp. NARCISSUS: Botrytis polyblastis, rare foliage disease. The occurrence of this fungus in 1953 in laboratory plots at Sumner, Washington was of special interest, as it was the first general appearance since 1934 when the disease was epidemic over the entire Puyallup Valley. Since then most of the commercial narcissus-bulb growers had sprayed the the foliage regularly with Bordeaux mixture. On the other hand fungicides had rarely been used in the laboratory plots at Sumner, which consequently served as an indicator of the absence of this disease in the intervening period. In general, there was no appreciable amount of infection in commercial narcissus plantings in Washington this season. (Charles F. Doucette, PDR 37: 556).

PELARGONIUM HORTORUM. GERANIUM: Xanthomonas hortorum, bacterial stem rot,

is limiting field production of geraniums in southern California, according to D. E. Munnecke. Observations indicated rapid spread by rain and overhead sprinkling. Field experiments were in progress to control the disease by selection of stock plants, field rotation, and sanitation in harvesting and handling of cuttings. (Phytopath. 43: 588).

PEPEROMIA OBTUSIFOLIA var. VARIEGATA: This ornamental is desired for its attractive foliage, and is grown on a large scale in southern California nurseries. For the past two years several troubles have been observed in this crop.

Rhizoctonia solani, cutting rot. Cuttings attacked by Rhizoctonia, the most frequent cause of this trouble, have brown water soaked areas in the petioles that sometimes extend into the leaf blades.

Oedema, presumably of virus origin, is typified by the appearance of small raised areas that give the leaf a pimply appearance. Satisfactory control was obtained by carefully roguing infected plants and selecting clean cuttings from healthy stock plants for propagation.

A perplexing disorder, which has been called "gray leaf" or "dirty leaf" was first noted in the summer of 1951. The disorder appeared gradually and occurred sporadically in the commercial houses.

Slugs feeding on the leaves caused large irregular brown areas over the surface. Excellent control was obtained with 15% metaldehyde dust at approximately 1 pound per 1000 sq. ft. (Munnecke and Chandler, PDR 37: 434).

ROSA spp. ROSE: Chalaropsis thielavioides, black mold, occurred for the first time in southern California in 1952-53, causing severe root injury in a glasshouse and a nursery, according to K. F. Baker. Infection originated in a nursery field, the root rot being aggravated by prolonged storage of the plants in wet moss and by excessive watering after planting in the glasshouse. Affected plants made satisfactory recovery when grown under drier conditions. (PDR 37: 430).

Cylindrocladium scoparium, crown canker. In Delaware, R. S. Cox reported 75 percent loss this year involving 24 acres. A loss of 10 percent is usual, due to failure of the cuttings to root for one reason or another. Thus the 1953 loss exceeded the normal 10 percent by 40 to 65 percent. The seriousness is appreciated when it is realized that the potential value of the planting on an acre basis is 10 to 16 thousand dollars. Apparently this is the first report of crown canker on roses in the field. (PDR 37: 447).

In the bulletin on roses for the home, Emsweller, McClellan and Smith stated in the well-illustrated section on diseases that black spot, Diplocarpon rosae, is the most serious and prevalent; control is effected by spraying or dusting with sulphur, sulphur lead arsenate, or ferbam. These sprays also control powdery mildew, Sphaerotheca spp., and rust, Phragmidium spp. (Home Gard. Bull. 25. 38 pp.).

Sphaceloma rosarum, rose anthracnose. R. A. Jehle and others reported additional records of spot anthracnose in Maryland. (PDR 37: 372).

SYRINGA spp. LILAC: Witches'-broom virus. Transmissibility of the lilac witches'-broom by grafting has been demonstrated by Paul Lorentz and Philip Brierley. This witches'-broom virus of Japanese lilac (S. japonica) has been found infectious to common lilac (S. vulgaris) and apparently also to Regel privet (Ligustrum obtusifolium var. regelianum). Because the source Japanese lilac grew for years in Takoma Park with no evidence of virus spread to other plants, it seems unlikely that an effective vector is present in this area. The virus cannot be considered a threat to lilacs unless such a vector appears. (PDR 37: 555).

VIBURNUM OPULUS var. ROSEUM. SNOWBALL: Sphaceloma viburni, snowball anthracnose. R. A. Jehle and others reported additional records of spot anthracnose in Maryland. (PDR 37: 372).

DISEASES OF SHRUBS AND TREES

Thorn and Zentmyer listed hosts reported for Phytophthora cinnamomi, first described in 1922 on cinnamon trees in Sumatra. Since then it has been reported on a wide variety of trees and shrubs in many different parts of the workd. (PDR 38: 47).

ACER spp. MAPLE: Tarjan and Howard reported detrimental effects of copper sprays to Norway maple (Acer platanoides) in Rhode Island. (PDR 38: 58).

In Vermont, Sproston and Scott reported Valsa leucostomoides as the cause of decay and discoloration in tapped sugar maples (Acer saccharum). (Phytopath. 44: 12).

ARECASTRUM ROMANZOFFIANUM. QUEEN PALM: (COCOS PLUMOSA) Ganoderma sulcatum, butt rot. The queen palm is widely planted in Florida and is relatively free of parasitic diseases. However, when surrounded by shrubs or planted in damp locations, it may be subject to butt rot. Childs and West describe this butt rot which is associated with G. sulcatum. (PDR 37: 632).

BETULA LUTEA. YELLOW BIRCH: Canker and decay of living yellow birch caused by Poria laevigata in the Monongahela National Forest was reported by R. P. True and others. (Phytopath. 43: 487).

CORNUS FLORIDA. DOGWOOD: Elsinoë corni, spot anthracnose. Driver and Plakidas reported that in April 1953, specimens of spot anthracnose of flowering dogwood were received from Monroe, Louisiana, along with a report that a similar condition had been observed on the same plants for the past three years. Specimens were later collected in the Baton Rouge area. (PDR 37: 448).

CRATAEGUS OXYACANTHA ROSEA. ENGLISH HAWTHRON: An English hawthorn tree which is annually defoliated during late summer in New Jersey by the leaf spot organism (Fabraea maculata) was selected for testing seven different fungicides. Data taken on September 3 showed partial disease control by captan and apparent suppression of the leaf spot disease by zineb and Manzate. (Dochinger and Bachelder, Phytopath. 44: 110).

JUGLANS REGIA. PERSIAN WALNUT: Phytophthora cinnamomi, cinnamon fungus. G. Flippo Gravatt warned of the menace constituted by this fungus to trees of the Pacific Coast. (PDR 38: 214).

LIGUSTRUM OVALIFOLIUM. PRIVET: Ringspot (virus). In 1948 ringspot symptoms were observed on a California privet hedge in College Station, Texas. The three transmission trials gave inconclusive results because of the lack of controlled greenhouse facilities. (PDR 37: 636).

LIQUIDAMBAR STYRACIFLUA. SWEETGUM: Investigations were reported on two diseases of sweetgum that resemble each other in some respects. Garren reported on leader dieback; and Young and others reported on the status of sweetgum blight in 1953. (PDR 38: 91, 93).

PINUS ELLIOTTI, SLASH PINE: Fomes annosus, a widely distributed root-killing fungus that attacks a variety of coniferous hosts, was found in 1952 in South Carolina on slash pine. Campbell and Hepting suggested that the fungus may become a factor of much importance. (PDR 38: 217).

PINUS STROBUS. WHITE PINE: The suggestion that Corticium galactinum may be the cause of white pine needle blight is not borne out by research by Richard J. Campana. (PDR 38: 297).

POPULUS spp. POPLAR: Various aspects of surface sterilization of poplar cuttings for disease control are discussed in two reports: Waterman and Aldrich (PDR 38: 96) reported results of investigations on methods of treatment and on efficacy and toxicity of fungicidal materials; Ford and Waterman reported effects on survival and growth of field-planted cuttings. (PDR 38: 101).

In Fresno County, California the walnut branch wilt organism, Hendersonula toruloidea, was isolated from dead poplar trees (P. fremontii) and from dead branches on living poplar trees. The symptoms on poplar were similar to those described on other hosts. (PDR 38: 238).

QUERCUS spp. OAK: Endoconidiophora fagacearum, oak wilt. T. W. Bretz reported that sterile distilled water was a useful medium for routine isolation of the oak wilt fungus (PDR 37: 630). More than one hundred different media were tested by Robert N. Campbell and David W. French in an attempt to find a selective medium for the slow-growing oak wilt fungus. A diamalt-oxgall formulation proved best. (PDR 37: 407).

The fungus was isolated from a wilting scrub oak (Quercus ilicifolia) in Pennsylvania. Scrub oak is not a commercial timber tree, but it has considerable economic importance in soil conservation and wild life (Fergus and Yount, PDR 37: 567). In experimental work in Illinois, two western oaks, the California live oak (Q. agrifolia) and the canyon live oak (Q. chrysolepis), were found to be susceptible (Hoffman, PDR 37: 527).

B. M. Zuckerman and E. A. Curl in Illinois reported proof that the fungus pads on oak wilt-killed trees are a growth form of E. fagacearum. (Phytopath. 43: 287). Charles L. Fergus reported results of Pennsylvania studies on the compatibility types isolated from single mycelial mats and from numerous mats formed on a single tree. Since all of the mats formed on each of the trees tested were of the same compatibility type, the logical assumption is that only one compatibility type mycelium was present in the wood of the infected tree. This evidence strengthens the conclusion that very few infected trees contain mycelium of both compatibility types of E. fagacearum. Results of this study support the hypothesis that some agent, perhaps an insect is necessary for spermatization and subsequent perithecial formation in nature, (see below), and offer additional proof that the mycelial pads are a growth form of E. fagacearum, since cultures from them developed typical endoconidia, perithecia, and ascospores. (PDR 37: 565). Both A and B strains of the oak wilt fungus were present in most areas from which isolates were obtained during the 1951-52 Pennsylvania oak wilt survey. The great majority of single tree isolates were of one strain only, but an occasional isolate was mixed, according to W. L. Mount. (PDR 38: 293). Barnett and Jewell reported evidence from West Virginia supporting the conclusion that only one compatibility type of the oak wilt fungus survives in most naturally infected trees. (PDR 38: 359). Oren W. Spilker reported Ohio studies on the sexuality of Endoconidiophora fagacearum. One isolate functioned only as a male in all tests. (PDR 37: 448). In the spring of 1953, a white mutant was isolated from the normally dark West Virginia culture No. 645, which was obtained from an oak wilt tree in 1951. The isolation of an albino form from a naturally infected tree strengthens the idea that the fungus is quite variable in nature as well as in pure culture. It is suggested that this mutant is capable of existing in nature and that its virulence may be as great as or greater than that of the fungus from which it arose. (Barnett, True and Brown. PDR 38: 121).

Dale M. Norris, Jr. in Iowa, and G. K. Dorsey and others in West Virginia reported successful experimental transmission of the oak wilt fungus by means of nitidulid beetles. (PDR 37: 417, 419). Experiments in West Virginia reported by Frederick F. Jewell showed that conidia of the oak wilt fungus survived passage through the intestinal tract of nitidulid beetles. (PDR 38: 53). According to experiments reported by John S. Boyce, Jr. nitidulid beetles reinfested oak wilt fungus mats over distances up to 500 feet at least. (PDR 38: 212). At the Ohio Agricultural Experiment Station endospores of the fungus were found on the legs and in the intestinal tract of several adults of Drosophila melanogaster that had fed upon and deposited eggs on sporulating mycelial mats. There was also reason to believe that Pseudopityophthorus minutissimus and P. pruinosus are concerned in the transmission of the disease. (Jour. Econ. Ent. 46: 708).

Results of limited experimental investigations on the relation of wounding to natural infection of oak trees by the oak wilt fungus were reported by F. C. Craighead et al. Wounded trees that became infected were all near diseased trees on which mycelial mats bearing fertile perithecia were produced during the period when the wounds were open (PDR 37: 483). Field observations in Pennsylvania in 1953 indicated that wounds made during the period of spring wood formation were of considerable importance in the primary spread of oak wilt. Wounds were incurred during various construction operations, from lightning injury, or from storm damage. The type of wound seemed to make little difference as long as the bark is injured sufficiently to expose the cambium. (Arthur R. Jeffery, PDR 37: 568). In Illinois greenhouse experiments on the relation of type and age of wound to infection, it was found that the longer the time between the making of the wound and the arrival of inoculum the less likely is infection to take place. Wounds not more than 24 hours old were most favorable. Infection occurred through torn or broken bark, torn leaf blades, and wounds made by breaking off the leaf stems at the point of attachment. No infection took place through wounded or broken-off buds. Infection through torn leaves suggests that leaf-feeding insects may sometimes act as vectors. (Bert M. Zuckerman, PDR 38: 290).

QUERCUS STELLATA. POST OAK: According to Campbell and Miller no definite cause was found for the deteriorated condition of the foliage of post oaks in the Southeast. Several trees that lost many leaves early in the season put out a new crop in September. The main symptoms were suggestive of drought injury, but other oaks usually considered more suscepti-

ble to drought than post oak appeared normal or nearly so even when growing in close association with post oak. Frost injury probably accounted for the crop of small deformed leaves early in the spring. (PDR 37: 628).

ULMUS spp. ELM: Ceratostomella ulmi, Dutch elm disease. D. S. Welch reported that studies at Cornell University, on this disease have shown that when elms are cut they are immediately invaded by bark beetles (Scolytus multistriatus and Hylurgopinus rufipes), coming from considerable distances. Control by timely removal of diseased trees and other beetle-breeding sources is practicable only if the lumber and landscape value justify the cost. Otherwise, in forest areas where the disease becomes established the prompt removal of all valuable elm in the immediate vicinity is necessary as soon as possible as no practical protection of timber under such conditions is known. (Jour. For. 51: 641, 643). During 1953, 495 new cases of Dutch elm disease were detected in 28 localities in 12 counties in Illinois. The disease was found in six new counties within the general area of distribution of the disease in 1952. Spread of the disease was accelerated by the large numbers of standing dead elms killed by the phloem necrosis virus disease. (PDR 38: 356).

DISEASES OF SPECIAL CROPS

ARACHIS HYPOGAEA. PEANUT: Heiberg and Ramsey reported fungi associated with diseases of peanuts on the market. About 2000 carloads of shelled peanuts are unloaded in Chicago each year, mostly Spanish and Runner types but with occasional lots of Virginia. At intervals during the past ten years samples of damaged peanuts from approximately 100 cars were studied to determine the cause of discoloration and decay of peanuts on the market. (Phytopath. 43: 474).

Puccinia arachidis, rust. Inspection of the field at the Georgia Plain Experiment Station in which rust occurred showed the area of infection small but the injury serious within the area. In Irwin County the damage was much more extensive and just as serious. (Harvey W. Rankin, PDR 37: 528).

BETA VULGARIS. SUGAR BEET: Ruga verrucosans, curly top virus. Thornberry and Takeshita reported the finding of the curly top virus in sugarbeets as well as in the leafhopper vector (Circulifer tenellus) in Illinois. Since the virus can attack many other crops and plants, its presence in association with the vector is of potential importance in the State and in the region. They discussed the relation of the virus to horseradish brittle root. (PDR 38: 3). Curly top of sugar beets has been known in Kansas but has been of little importance. In 1953 a severe epiphytotic was reported in the Garden City-Scott City irrigated growing areas. Tonnage was reduced approximately 50 percent per acre but percentage of plant infection was higher. Resistant varieties were not being grown in the area. The vector was found in some abundance at different times. During the spring high winds leafhoppers apparently were blown in from the southwest or else possibly picked up enroute from some of the many known available natural hosts. (W. H. Sill and others, PDR 38: 57).

N. J. Giddings reported two recently isolated strains of curly top virus. An extremely virulent strain was discovered in sugar beets and in field collections of beet leafhoppers. It is most prevalent in southern Idaho but was also found in southern California. It has been designated as strain 11. (Phytopath. 44: 123). According to C. F. Lackey, investigations at the Division of Sugar Plant Investigation, Riverside, California, revealed that the vascular bundles of sugar-beet leaves and petioles exert an external attraction for the leafhopper, Circulifer tenellus and for haustoria of dodder, Cuscuta spp. (Amer. Jour. Bot. 40: 221).

GOSSYPIUM spp. COTTON: Losses from disease: In an article on plant disease loss estimates (PDR 37: 171), Paul R. Miller critized the erroneous and inadequate estimates of cotton losses due to diseases in the United States for the period from 1909 to 1939 published by the Bureau of Agricultural Economics. In comparison with the figures issued in the Plant Disease Survey's Crop Loss Estimates for the period from 1917 to 1939, the former estimates were too small, geographical and seasonal differences were not considered, and a wrong impression was given of the importance of disease in cotton production. Attention was called to the danger of publishing such unreliable information in view of its possible consequences to research and it was urged that the value of disease losses should be considered by pathologists as a necessary part of their investigations. Figures in obtaining estimates should be reliable and up-to-date.

Tabulated summaries of the reductions in cotton yield due to diseases were compiled by the Cotton Disease Council's Committee on Disease Losses in 1952 (PDR 37: 176), and 1953 (PDR 38: 223). Verticillium albo-atrum caused the greatest loss.

Evaluation of control chemicals: C. H. Arndt reported a new sand-culture technique developed at the Clemson, South Carolina Agricultural Experiment Station for evaluating chemicals as cotton seed and seedling protectants, using Rhizoctonia solani as a test organism. (PDR 37: 397).

Ascochyta gossypii, blight. In Georgia, J. H. Miller reported a preliminary study of tribasic copper in control of Ascochyta blight. (Phytopath. 43: 292).

C. H. Arndt reported survival of Colletotrichum gossypii on cotton seeds in storage. (Phytopath. 43: 220).

James M. Epps and others reported that during the period 1951-53 the average annual loss in Tennessee from cotton wilt (Fusarium vasinfectum and Verticillium albo-atrum) damage was estimated at 9,209 bales valued at $1,197,000. Of this loss 62 percent was due to Fusarium wilt and the balance to Verticillium wilt. This loss did not include acreage abandoned because of disease or the effects of wilted cotton on grade. Significant average annual losses occurred in the five Delta counties of Lauderdale, Tipton, Shelby, Lake, and Dyer, and in the upland cotton-producing counties of Crockett, McNairy, Gibson, Madison, and Fayette. Losses in nine other counties of West Tennessee were not significant for the county as a whole but may have been of importance on individual farms heavily infested with wilt. (PDR 38: 304).

Thielaviopsis basicola, black root rot. L. M. Blank and others reported that the absence of nematodes in steamed artificially-infested soil, or their presence in naturally-infested field soil, did not alter the pathogenicity of T. basicola on American-Egyptian cotton seedlings grown at several soil temperatures in the greenhouse. With average soil temperatures of 69°, 77°, and 79° F. the disease expression was most severe at the lowest temperature. At higher temperatures, stunting of the plant was the characteristic above-ground symptom. (PDR 37: 473). Root rot or "internal collar rot" due to T. basicola was observed in cotton at the Shafter California Field Station in the fall of 1953. The symptoms were typical of those occurring on mature plants. (J. T. Presley, PDR 38: 529).

Tylenchorhynchus dubius, stylet nematode, a root parasite, has been found to be of economic importance in the Southwest. Results of experiments with the stylet nematodes suggest that the control of these and possibly other ectoparasitic nematodes, rather than a nitrogen transformation in the soil, accounts for much of the increase in growth, obtained from soil fumigation. (Reynolds and Evans, PDR 37: 540).

Verticillium albo-atrum, wilt. (See also under losses and under Fusarium, above). Surveys during the summer of 1953 showed that Verticillium wilt of cotton was considerably more prevalent in Arizona than had been realized, according to Ross M. Allen. (PDR 38: 36). The concentration of salt in the soil seemed to be a factor in severity of cotton Verticillium wilt, according to observations reported from Texas by P. D. Christensen and others. (PDR 38: 309).

Xanthomonas malvacearum, bacterial blight, occasionally appears in epiphytotic form in the Pecos Valley of New Mexico. A three-year study was made of the role of carry-over of the causal organism from season to season in initiating epiphytotics. Infected seedlings were found in two of three plantings in 1951, in one of two plantings in 1952, and in both of two plantings in 1953. It is evident that the bacteria can survive through the winter in the soil under New Mexico conditions and infect the following season's crop. (Blank and Hunter, Proc. So. Agri. Workers, p. 156, 1954).

Nub rot, an apparently undescribed seedling disease of cotton as expressed in the mature plant. Widespread losses were noted in 1952 and 1953 in Texas. In the field the first symptom of the disease is a sudden wilting. (Robert and Whitehead. Proc. So. Agri. Workers, p. 156, 1954).

P. B. Marsh and others summarized published information on the effect of pre-harvest weathering on the properties of cotton fibers and presented certain new information on the subject. (PDR 38: 106).

HIBISCUS CANNABINUS. KENAF: Colletotrichum hibisci, dieback. Thomas E. Summers reported the existence of three physiologic races of C. hibisci on kenaf in Florida in 1953. In the separation of these races pure line selections of kenaf were used. (PDR 38: 483). C. hibisci causes a serious disease which menaces commercial plantings of kenaf in southern Florida. J. B. Pate reported the development of lines of kenaf that seemed to be highly resistant. (Phytopath. 43: 647).

MENTHA spp. MINT: Effects of several nematodes found closely associated with or causing disease in mints in Western Oregon, during 1952 and 1953, were reported by Horner and Jensen. (PDR 38: 39).

Puccinia menthae, rust, was observed for the first time in eastern Washington in July 1953. The disease was found only in one planting of spearmint (M. spicata), in a small portion irrigated by an overhead sprinkler. Rust was severe within the area covered by the sprinkler but was not found in the rest of the field until October. This observation was significant because a rapid increase in acreage of spearmint and peppermint (M. piperita) has occurred in the irrigated areas following damaging outbreaks of mint rust in the important growing section on the Pacific Coast. (J. D. Menzies, PDR 38: 314).

NICOTIANA spp. TOBACCO: E. E. Clayton reported that sources of resistance to the major diseases are available in N. tabacum, but that so far it has proved impracticable to utilize even half this material in the development of commercial varieties, the non-usable portion having been consistently defective in plant type, yield, or quality. Except for its reaction to Ambalema mosaic virus, the inheritance of resistance obtained within N. tabacum is polygenic. Notwithstanding those handicaps an entire series of valuable commercial varieties has been produced, carrying different degrees of resistance to black root rot (Thielaviopsis basicola), black shank (Phytophthora parasitica var. nicotianae), bacterial wilt (Pseudomonas solancearum) and Fusarium wilt (F. oxysporum var. nicotianae). Immunity from or very high resistance to the principal diseases of the crop has further been found in various wild species of Nicotiana. Transfers to tobacco of simple monogenic dominant immunity from mosaic and wildfire (P. tabacum) have already been accomplished, while great progress has been made in the incorporation of root rot immunity and the resistance to blue mold (Peronospora tabacina) carried by N. debneyi. The author pointed out that there is every indication that transfers from such distant relatives, once established in tobacco, can be used far more rapidly and with fewer complications affecting type, yield, and quality than is the case with any resistance found within the cultivated species itself. (Phytopath. 43: 239).

In North Carolina, Apple and Lucas pointed out the effectiveness of various field inoculation procedures in testing tobacco for black shank resistance. (Phytopath. 43: 289).

Oidium sp., powdery mildew, was observed on the leaves of burley tobacco plants growing in a greenhouse at Lexington, Kentucky. The disease did not spread over the plants as they grew and was not observed on older plants. The inoculum was apparently provided by a nearby hybrid, Nicotiana bonariensis x N. alata, that was thoroughly covered by powdery mildew. (R. A. Chapman,PDR 37: 528).

Peronospora tabacina, blue mold. In further studies at the University of Delaware Experimental Farm on aerial dissemination of tobacco blue mold, infection was found on June 15, 1953, in a new plant bed, according to R. A. Hyre. The nearest plant beds, about 20 miles away near Homeville, Pennsylvania, were free from the disease on June 16 and only one bed with blue mold was reported from Lancaster County. A planting of an ornamental species of Nicotiana at Newark was not affected. It was concluded that inoculum for the infection at Newark was again wind-borne for at least 20 miles. (PDR 37: 447).

Lucas and Person described the procedure by which they obtained germination of oospores of the tobacco blue mold fungus. (PDR 38: 343).

W. D. Valleau reported that there are two known ways in which the blue mold fungus survives from year to year; one is on live plants that survive the winter in Georgia, and the other is by means of oospores in beds used a second year. Elimination of these two means of overwintering in Georgia should immediately eliminate the fungus in that area. In the Tennessee-Kentucky area, which is out of the direct line of spore movement north from Georgia, the fungus is dependent almost entirely on oospores for survival and is not able to maintain itself year after year. The Carolina-Virginia area is subject to spore showers from the South as well as infection from overwintering oospores; consequently the fungus persists year after year. Presumably the elimination of spore showers from the South in the Carolinas would result in the gradual disappearance of the fungus there just as in the Tennessee-Kentucky area. The proposal to use new beds and destroy over-wintering tobacco plants is practical in view of the well organized extension service in the States concerned. (Phytopath. 43: 616).

Blue mold, according to reports to the Plant Disease Warning Service was widespread in practically all of the tobacco-growing area of Georgia, North Carolina, and throughout the southern part of the flue-cured area of Virginia. It was also reported from Florida, Kentucky, Maryland, South Carolina, and Tennessee. It was found on shade tobacco in one field in Hartford County, Connecticut. There was practically no measurable damage in 1953 and plants were

plentiful. G. S. Taylor reported the control of tobacco blue mold by root application of zineb and ferbam. (Phytopath. 43: 486).

W. D. Valleau reported a probable solution of the calcium cyanamide problem in tobacco bed weed control in Kentucky. The present program for wildfire (Pseudomonas tabaci) control, of using the same site year after year, sowing the bed to soybeans or some other fast growing cover immediately after the crop is set, plowing the bed in the fall, and treating for weed control, should fit into the cyanamide weed control program perfectly. (PDR 37: 410).

Tylenchorhynchus claytoni, tobacco stunt nematode, an ectoparasitic species, occurred generally in tobacco soils in eastern South Carolina. It was present in 67 percent of 175 soil samples collected from fields where tobacco was stunted (1951 through 1953), and proved to be parasitic on tobacco in the greenhouse and field trials. (T. W. Graham, (Phytopath. 44: 332).

Paul D. Keener reported natural infection of non-cultivated datura (Datura meteloides) and tree tobacco (N. glauca) with a strain of the tobacco mosaic virus in Arizona. Perhaps some unrecognized vector exists. A recent report confirmed the fact that at least some mealybug species are capable of transmitting tobacco mosaic virus. (PDR 38: 330).

"False broomrape" as described by Valleau from Kentucky (PDR 37: 538) had been noticed in Alachua County, Florida in 1951 and again in 1952. The disease at first glance had all the appearances of the broomrape parasite but more detailed examination showed no indications of that plant. Many possible explanations have been offered. (PDR 38: 122).

Moorhead and Price reported a new serological test for tobacco mosaic virus devised at the Plant Virus Laboratory, University of Pittsburgh, Pennsylvania. (Phytopath. 43: 73).

The relation of host nutrition to multiplication of viruses in Nicotiana was reported by Pound and Weathers for turnip virus 1 in Nicotiana glutinosa and N. multivalvis. (Phytopath. 43: 669). and by Weathers and Pound for tobacco mosaic virus in tobacco. (Phytopath. 44: 74).

PARTHENIUM ARGENTATUM. GUAYULE: Fusarium solani, root rot, on guayule was described by Don C. Norton. The disease was found in 1951, 1952, and 1953 in Texas. Inoculation tests and field observations indicated that the pathogen is not highly virulent under customary growing conditions. (PDR 38: 500).

RICINUS COMMUNIS. CASTORBEAN: Observations on diseases of castorbean in 1953 were reported by D. Donald Poole. Castorbeans were grown on over 100,000 acres in Texas and Oklahoma in 1953. The Connor variety, which is susceptible to bacterial leaf spot (Xanthomonas ricinicola), was planted on 75 percent of this acreage. The disease was found in 66 counties in Texas and 12 in Oklahoma. It reached almost epiphytotic proportions in some areas of southern and eastern Texas and southcentral Oklahoma and serious losses occurred. Variety observation plots planted in Louisiana, Alabama, Maryland, and two locations in Florida revealed the presence of the pathogen in every instance. (PDR 38: 218).

SACCHARUM OFFICINARUM. SUGARCANE: Evidence for the occurrence of a hitherto unrecognized growth-retarding disease of sugarcane showed up in Louisiana, according to E. V. Abbott. The symptoms resembled those of ratoon-stunting virus disease in Australia. (Phytopath. 43: 289).

SESAMUM spp. SESAME: G. M. Armstrong reported two new locations for Fusarium wilt of Sesame. During the summer the county agent at Savannah, Georgia, sent in specimens. A new location for the sesame breeding work at Clemson was established last summer, 1952. In August 1953 Fusarium wilt was found. (PDR 38: 57).

DISEASES OF VEGETABLE CROPS

In two articles on vegetable seed treatment, V. R. Wallen reported tests with seed treatment materials for improved emergence (PDR 37: 620); and the best strength of Panogen to use for vegetable seed treatment (p. 623). Results of vegetable seed treatments in Louisiana were reported by W. J. Martin and J. G. Atkins. (PDR 38: 348). Kendrick and Middleton reported results of a study designed to test certain fungicides against a wide variety of soil-borne pathogens and against some citrus and tomato fruit pathogens. They also described a technique used in their tests of certain chemicals for use as fungicides. (PDR 38: 350). Tests on the

practicability of using solid materials as carriers for soil fumigants in nematode control were reported in two articles: Taylor and Golden (PDR 38: 63) reported results of experiments with D-D Hi-Sil; and Sasser and Nusbaum gave results with vermiculite as a carrier for various compounds. (PDR 38: 65).

ALLIUM ASCALONICUM. SHALLOT: Pyrenochaeta terrestris, pink root. E. C. Tims has given a general discussion of pink root, a serious soil-borne disease in southern Louisiana shallot-growing area, with results of studies and observations over a ten-year period. The amount of disease can be greatly reduced by selecting pink root-free sets or green transplants. (PDR 37: 533).

ALLIUM CEPA. ONION: Alternaria porri, purple blotch, has become one of the limiting factors in onion production in the Arkansas Valley of Colorado. Estimated losses in field and storage often have ranged from 30 to 50 percent and have sometimes been as high as 100 percent. (Phytopath. 43: 409).

Urocystis cepulae, smut. According to Larson and Walker most of the better upland soils in the Racine-Kenosha area of Wisconsin are contaminated with the smut fungus, and with many successive crops of onion this fungus has increased to such an extent that without the use of adequate control measures, onion sets cannot be grown profitably. Six years of experimentation in this area demonstrated that onion smut can be effectively controlled by the use of thiram in onion set plantings. (Phytopath. 43: 596).

APIUM GRAVEOLENS. CELERY: Deficiency diseases. Heredity and nutrition in relation to magnesium deficiency chlorosis in celery was discussed by Pope and Munger. Several celery varieties growing in organic soils in New York developed a severe chlorosis, which was remedied by spraying affected plants with magnesium sulphate solution. In genetical experiments crossing a chlorotic variety with a normal one showed that a single dominant gene conditioned the utilization of magnesium. (Proc. Amer. Soc. Hort. Sci. 61: 472). These authors also reported the inheritance of susceptibility to boron deficiency in celery. (Proc. Amer. Soc. Hort. Sci. 61: 481). According to Davis and McCall magnesium deficiency in celery was observed for the first time in Michigan in 1946. The disturbance, which occurs in most of the main celery-producing areas in the State, is characterized by the progressive mottling and yellowing of the tips, margins and the interveinal areas of the older leaves. Necrotic areas appear later and often much of the blade becomes dead and dry. In experiments carried out at Muck Experimental Farm spray applications of magnesium sulphate at 10-day intervals throughout the growing season appeared to control deficiency in Utah 10-B variety and to increase yield. This was the most susceptible variety whereas Summer Pascal was much less so, and Utah 15 showed no symptoms. (Quart. Bull. Mich. Agr. Exp. Sta. 35: 324).

Swank and Perry reported control of diseases (Rhizoctonia solani, Pythium sp. and Fusarium sp.) in celery seedbeds with methyl bromide at Sanford, Florida. (Fla. Agri. Sta. Circ. S-55, 8 pp.).

On the basis of 41 contributions to the literature, Munger and Newhall discussed two aspects of breeding celery and cucurbits for resistance to specific diseases, namely, the best sources of resistance for use in a breeding program and the possibilities of transferring resistance from one variety to another. (Phytopath. 43: 254).

BRASSICA OLERACEA var. BOTRYRIS. BROCCOLI, CAULIFLOWER: Smith and Ramsey reported that in February 1952, specimens of diseased broccoli from a carlot grown in the vicinity of Oceano, California were received at Chicago, Illinois. The inspection showed that 25 percent of the bunches in some crates were diseased. After much study this disease was considered identical with Pseudomonas maculicola. (Phytopath. 34: 583).

Lee Campbell summarized results of tests with various chemicals for the control of club root, Plasmodiophora brassicae, on cauliflower, in Washington. (PDR 38: 283).

BRASSICA OLERACEA var. CAPITATA. CABBAGE: Peronospora parasitica, downy mildew. Huey I. Borders summarized results of tests with fungicides for the control of downy mildew of cabbage seedlings in Georgia. (PDR 37: 363).

CAPSICUM FRUTESCENS. PEPPER: The results of a survey reported by R. S. Cox indicated that the bacterial leaf spot (Xanthomonas vesicatoria) epiphytotic in Delaware in 1953 was the result of primary inoculum introduced from Georgia with transplants. The previous crop had no effect on disease incidence. (PDR 38: 83).

Internal mold, a marketing problem of sun-dried chile produced in New Mexico, is caused

primarily by species of Alternaria, Fusarium and Hormodendrum. The disease was reduced by spray application of fungicides. Phygon XL gave the best control, followed by Zerlate, Dithane, and Copper-Hydro. One application applied the day after frost gave the best results. (PDR 38: 32).

Ringspot (virus). Doolittle and Zaumeyer reported that sweet pepper in New Jersey, Maryland, Delaware, and adjacent States was affected with a mosaic disease characterized by mild green mottling of the foliage accompanied by large chlorotic rings and oak-leaf markings on the older leaves and concentric yellow rings on the fruits. This ringspot, caused by strains of cucumber mosaic virus from pepper and alfalfa, often caused appreciable damage in some fields. (Phytopath. 43: 333).

CITRULLUS VULGARIS. WATERMELON: Pimples, sometimes referred to as bumps, meales, sandbumps, or warts. David W. Rosberg reported association of a strain of the tobacco ringspot virus with the pimples disease of watermelon fruit in Texas. This disease has increased annually in the State during the last few years. Similarity of pimples to early fruit lesions of anthracnose (Colletotrichum lagenarium) has been found to be a major problem in grading for shipment. (PDR 37: 392).

CUCURBITS. CUCUMBER, MELON, SQUASH: Cladosporium cucumerinum, cucumber scab, was rather severe in certain fields in Connecticut, just as it had been in the 1952 growing season, according to Saul Rich. (PDR 37: 636).

Colletotrichum lagenarium, anthracnose, in Sumter County, Florida, seemed to be rather uniformly distributed throughout the entire cucumber area, causing more damage than any other disease, and appeared to be much more severe than in previous years. Eighty percent of the fields had from 20 to 30 percent infection. One 4-acre field showed 100 percent infection. (Owen and Connell, PDR 37: 327). In North Carolina, Libby and Ellis reported the transmission of the anthracnose fungus, of cucumber by the spotted cucumber beetle (Diabrotica undecimpunctata). They found no other reference in the literature to the transmission of C. lagenarium by cucumber beetles. (PDR 38: 200).

Pseudomonas lachrymans, bacterial leaf spot, of Zucchini squash was reported in the Colma area, near San Francisco, California. This seemed to be the first report of this organism on field-grown squash, according to Peter A. Ark. (PDR 38: 201).

Pseudoperonospora cubensis, downy mildew, of cucumber in Sumter County, Florida, appeared to be well under control in fields where growers were spraying twice weekly with nabam and zinc sulfate, or dusting with zineb. In fields where growers were alternating with zineb and copper dusts or were not following a rigid spray program, downy mildew infection ranged on the average from 10 to 20 percent. Only one field had 100 percent infection. (Owen and Connell, PDR 37: 327). Cucurbit downy mildew occurred again in 1953 but damage was slight according to reports received by the Plant Disease Warning Service. It caused moderate losses in local watermelon plantings in South Carolina but was not a serious financial factor on cantaloupes in the same State, as the crop was extremely short because of the hot, dry weather of May and heavy infestations of the root knot nematode.

DAUCUS CAROTA. CARROT: Alternaria dauci, Alternaria blight, frequently causes substantial damage in certain sections of Eastern Pennsylvania and may cause some damage in New Jersey. Fungicide tests have shown statistically significant increases in yield of 7 to 8 tons per acre with manganese ethylene bisdithiocarbamate, and 5 to 6 tons per acre with zineb. (Weber and others, Phytopath. 44: 112).

IPOMOEA BATATAS. SWEETPOTATO: A disease of Porto Rico sweetpotato roots in Louisiana, known as circular spot, was recently found to be due to Sclerotium rolfsii and not connected with soil rot (Streptomyces ipomoea), with which the disease was thought for years to be associated, or with surface rot (Fusarium sp.) or mottle necrosis (Pythium sp.). (Phytopath. 43: 432).

Internal cork (virus). L. J. Kushman and M. T. Deonier reported the results of a survey of internal cork of sweetpotatoes in Mississippi in 1952. Some was present in more than 80 percent of the Porto Rico stocks sampled, and it was serious in about one-fourth of them. The disease was found in all sections of the State sampled. (PDR 37: 614). G. D. Freazell reported reaction of sweetpotato varieties and seedlings to internal cork disease in Louisiana. (Phytopath. 43: 290). Nielson and Person reported experimental data and observations that demonstrated spread and increase of the internal cork disease in North Carolina. The rate of

spread and increase suggested that an insect vector (or vectors) was present in all sweetpotato growing areas. Rankin reported Myzus persicae to be a vector in Georgia. (PDR 38: 326).

Mosaic (virus). Borders and Radcliff reported a mosaic of sweetpotato in plant beds and fields in Georgia. In early fall of 1952 inspectors found a number of sweetpotato fields in which almost 100 percent of the vines were infected by what appeared to be a virus. The results of one season's experiment indicated that the virus is not soil-borne but is carried by an insect vector. (PDR 38: 6).

LACTUCA SATIVA. LETTUCE: Results of cross-inoculations and pathogenicity tests with New Jersey isolates of Sclerotinia sclerotiorum, S. minor, and S. trifoliorum were reported by Victor M. Held and C. M. Haenseler. (PDR 37: 515).

Big vein (virus) was not so generally severe this year in Connecticut as it had been in previous years. In at least one field, however, about 85 percent of the plants showed symptoms of big vein. (Saul Rich, PDR 37: 637). Results of studies reported by C. E. Yarwood suggested a connection between tobacco-necrosis virus and lettuce big vein in California. (PDR 38: 263).

Mosaic (virus). G. W. Bohn reported that mosaic caused important losses in the late fall and early winter crops of lettuce in the Imperial Valley, California, and the Yuma Valley, Arizona, during the 1952-53 growing season. The unusual prevalence of the disease appeared to be correlated with an unusual abundance of aphids and other insects. Temperatures averaged about 10^{o} F. above normal. Probably this was an important factor in the build-up and activity of the insect population. There is proof that this disease can be controlled by planting mosaic-free seed. (PDR 37: 134).

Lettuce injury from 2, 4-D has been found over extensive areas in the Salinas Valley, California, according to E. R. de Ong. (PDR 37: 410).

LYCOPERSICON ESCULENTUM. TOMATO: George Swank, Jr. reported the perfect stage of Colletotrichum phomoides on tomato to be Glomerella phomoides Swank sp. nov. (Phytopath. 43: 285).

Fusarium oxysporum f. lycopersici, Fusarium wilt, was more common on field tomatoes in Connecticut than it has been in previous years. (Saul Rich, PDR 37: 637).

Fusarium oxysporum f. lycopersici, wilt. The cause of epinastic symptoms in Fusarium wilt of tomatoes was discussed by Dimond and Waggoner. (Phytopath. 43: 663).

Meloidogyne incognita, root-knot nematode. Increased photoperiods and warm temperatures resulted in abundant production of egg masses by the root-knot nematode, according to A. C. Tarjan and B. E. Hopper (PDR 37: 313).

Phytophthora infestans, late blight, see also under potato. The distribution of potato and tomato late blight as reported to the Plant Disease Warning Service in 1953 was somewhat widespread particularly on potato, but severity on both crops was relatively light. In many States blight did not appear at all or appeared in one or two scattered fields. Two occurrences of blight on tomato transplants were reported, in Charleston County, South Carolina, and in central Indiana where tomato blight was widespread despite the hot, dry weather. Rigorous spray schedules, the absence of inoculum owing to the prolonged hot, dry weather of the early summer, and adequate amounts and availability of fungicides were factors in preventing the appearance or distribution of blight in 1953. Late blight caused no damage to tomatoes in Connecticut, according to Saul Rich. (PDR 37: 637). The occurrence of a virulent race, not present in previous seasons, of P. infestans on late blight resistant tomato stock was reported by Conover and Walter in Florida. (Phytopath. 43: 344).

Sclerotium rolfsii, southern blight. An epiphytotic of southern blight occurred near Jacksonville, Texas, in 1953. Uncontrolled by crop rotation with corn and cotton, southern blight killed 55 percent of 1748 tomato plants in one acre and 91 percent of 1533 tomato plants in another acre. It also killed 89 to 100 percent of the plants of ten varieties of tomatoes in a yield test. Chlorobromopropene gave good control. (Phytopath. 44: 334).

Robert A. Conover reported good control of bacterial spot (Xanthomonas vesicatoria) on tomato and pepper in Florida with Agrimycin. (PDR 38: 405).

Internal browning. Saul Rich reported negative results from attempts to induce tomato internal browing in the field in Connecticut. The cause of the trouble is still obscure. (PDR 37: 614).

Potato virus Y. Infection by potato virus Y, either alone or in combination with tobacco mosaic virus, has occurred in Florida tomato fields in most seasons since 1947. The combined effect of the viruses is much more severe than that produced by either alone: plants practically cease growing and fruit production is greatly reduced, the leaves show a pronounced

yellow mottle and are stunted and distorted, and the fruits are misshapen. The 1952 spring crop suffered severe losses, some 3,000 to 4,000 acres of tomatoes being affected. It was suggested that weeds are one of the primary sources of virus Y. (Concver and Fulton, PDR 37: 460).

Sandstorm damage. About May 1 an unprecedented and most unusual sand storm blew across the sandy tomato land at Yoakum, Texas. It riddled all of the fruit on tomato vines in its path and in numerous instances completely destroyed the plants. Estimated damage to the crop was set at 50 percent. (E. M. Hildebrand, PDR 37: 445).

PHASEOLUS VULGARIS. BEAN: In greenhouse and field trials at the Plant Industry Station, Beltsville, Maryland, streptomycin sulphate sprays gave good control of bean halo blight (Pseudomonas medicaginis f. phaseolicola). Two applications would probably be sufficient for practical farm use. (Seed World, 73: 38). John W. Mitchell and others reported the absorption and translocation of streptomycin by bean plants and its effect on the halo and common blight (Xanthomonas phaseoli) organisms. (Phytopath. 44: 25).

The white mold (Sclerotinia sclerotiorum) disease is considered an important disease in Idaho. Current season infection by mycelium of the fungus may occur on bean plants from infested soil, from sclerotia, from decayed bean seed and from decayed stem and leaves of bean plants. The fungus was not able to survive the winter and cause infection by vegetative growth after overwintering in the soil 2, 4, and 6 inches deep. There was some seed borne disease. (Hungerford and Pitts, Phytopath. 43: 519).

Uromyces phaseoli var. typica, bean rust, In 1952 Fisher reported the reaction of 30 races of rust, on differential bean varieties. During the same year collections of bean rust were made in three areas of pinto bean production in New Mexico. Two of the collections were identified as a new race to be called race 31. (W. P. Sappenfield, PDR 38: 282).

Alfalfa mosaic virus. Isolation of strains of alfalfa mosaic virus causing a systemic mottle in beans from snap beans growing in Idaho and Washington showed that they are responsible for some of the leaf mottling observed in the field. Preliminary data suggested that the reddish-brown blemish of bean pods observed in this area may be caused by strains of alfalfa mosaic virus. (H. R. Thomas, PDR 37: 390).

C. E. Yarwood reported that zinc increases susceptibility of bean leaves to tobacco mosaic virus. (Phytopath. 44: 230).

PHASEOLUS LIMENSIS. LIMA BEAN: In California, L. D. Leach and others reported that 33 field trials were conducted in 1950, 1951, and 1952, to obtain information concerning the efficacy of certain combination fungicide-insecticide seed treatments. In nearly all of the trials, stands were materially improved by the use of a good fungicide. Soil insects were of minor importance in all trials except two. (PDR 38: 193).

PISUM SATIVUM. PEA: Frank P. McWhorter discussed the virus disease complex in canning peas. He reported evidence indicating that mingling of viruses may extend the host range of a single virus. All recent data from field studies and greenhouse analysis point to an interrelation of alfalfa and aphids as the explanation of present virus problems in peas in the in the Northwest. (PDR 38: 453)

RAPHANUS SATIVUS. RADISH: Fusarium oxysporum f. conglutinans race 2, Fusarium wilt. This destructive wilt in Wisconsin, as reported by Pound and Fowler, was characterized by chlorosis, necrosis, and abscission of the foliage, vascular discoloration of the roots, stems, petioles and marked stunting of the root. (Phytopath. 43: 277).

RHEUM RHAPONTICUM. RHUBARB: Ringspot-like virosis. Yale and Vaughan described symptoms, including chlorotic spots and rings, as well as necrotic stippling and rings, observed on the leaves of rhubarb in the Willamette Valley of Oregon. The virus was transmitted to healthy rhubarb and other hosts. Inoculation tests showed that this virus occurs in naturally infected curly dock in the field. (Phytopath. 44: 118).

SOLANUM TUBEROSUM. POTATO: Phytophthora infestans, late blight, see also under tomato. Studies to determine whether solutions of certain antibiotics will prevent infection of potato plants by the late blight fungus were reported by Reiner Bonde. None of the antibiotics when applied to the soil prevented or reduced infection. (Phytopath. 43: 463).

R. A. Hyre reported that an improved method had been developed for forecasting late blight of potato and tomato, based on an analysis of rainfall and temperature data by means of

moving graphs. Predictions for Connecticut would have been 83 percent correct in the 52-year period of 1902-53, inclusive. More important, blight would have been predicted every year that it occurred. Use of this method would have predicted late blight of potato at Ithaca, New York, in 1928, and late blight of tomato on the west coast of Florida in 1945-46, when occurrence was attributed to cool nights with heavy dew, and to long periods of high humidity, respectively. (PDR 38: 245).

According to Iowa experiments reported by W. J. Hooker, soil treatment with pentachloronitrobenzene gave good control of scab (Streptomyces scabies) and scurf (Rhizoctonia solani). (PDR 38: 187).

Synchytrium endobioticum, wart. According to R. A. Hyre the total destruction procedure used in the eradication of potato wart by the Pennsylvania Department of Agriculture, which was successful in limited tests, consisted in keeping the land clean and cultivating it frequently for the first two years, applying copper sulfate the first and an equal amount of lime the second, growing several varieties of vegetables the third year, and potatoes the fourth. R. E. Hartman compiled a tabulated summary, giving the progress made since 1952 and plans for the future. (PDR 37: 453).

Calico (virus). Donald Folsom reported occurrence of the potato calico virus disease in Maine. Potato calico virus and tuber necrosis virus both spread to potatoes from alfalfa and Ladino clover fields. (PDR 37: 347).

Curly top virus. Potato "haywire" in some sections resulted from tuber infection by the curly top virus, according to observations reported by W. S. Gardner in Utah. "Haywire" has not been reported from the Pacific States where curly top has been identified. (PDR 38: 323). A curly top virus strain that readily infects commercial potato varieties was first obtained from eastern Washington in 1950 and from potato fields in southern California during 1952. It is also highly virulent in tomato. Tests from potatoes indicated that the virus concentration was rather low in them. This virus has been designated as strain 12. (N. J. Giddings, Phytopath. 44: 123).

Glassy-end and jelly-end rot (non-parastic). B. A. Friedman and Donald Folsom described these rots of potato tubers as observed in the Northeast in 1949 and 1952. During both years the growing seasons were characterized by hot, dry weather followed by ample rainfall. (PDR 37: 455).

Stevenson and Akeley reported control of diseases of potato by disease resistance. Resistance to a number of diseases in both the wild and cultivated species has been found. (Phytopath. 43: 245).

PLANT DISEASE EPIDEMICS AND IDENTIFICATION SECTION

THE PLANT DISEASE REPORTER

Issued By

PLANT DISEASE EPIDEMICS
and
IDENTIFICATION SECTION

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

SUPPLEMENT 230

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Supplement 230 Issued June 15, 1955

The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Plant Disease Epidemics and Identification Section serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

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Horticultural Crops Research Branch
Supplement 230

Plant Industry Station, Beltsville, Maryland
Index to Supplements, 1954

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ERRATA

On page 78, line 14, read *Fusarium oxysporum*, instead of *Fusarium oxysporium*

On page 114, 1st line of title read VARIATION IN PATHOGENICITY instead of VARIATION IN PATHOGENCITY.

On page 131, under Fan Palm read (Washingtonia filifera) instead of (Washington filifera)

On page 148, 3rd paragraph, line 8, read Pseudomonas solanacearum instead of Pseudomonas solancearum.